ANIMAL HUSBANDRY AND FISHERIES RESOURCES DEPARTMENT GOVT. OF BIHAR

Training Manual

Hands-on Training

on

"Advanced Diagnostic and Therapeutic Techniques in Veterinary Practices"

(01-05 July, 2025)

Directorate of Extension Education

Bihar Animal Sciences University, Patna-14

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Sponsored by:

ANIMAL HUSBANDRY AND FISHERIES
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Organized by:

Directorate of Extension Education
Bihar Animal Sciences University, Patna-14

Editor In-Chief
Dr. Umesh Singh
Director Extension Education, BASU, Patna

Editors
Dr. Mritunjay Kumar
Associate Professor
Department of Veterinary Medicine
Bihar Veterinary College
Bihar Animal Sciences University (BASU), Patna.

Dr. Y. S. Jadoun
Associate Professor & Head
Department of Diary Extension Education
Sanjay Gandhi Institute of Diary Technology (SGIDT)
Bihar Animal Sciences University (BASU), Patna.

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CORE TEAM MEMBERS OF THE TRAINING

Chairman
Dr. Umesh Singh
Director Extension Education, BASU, Patna

Course Director
Dr. Saroj Kumar
Associate Professor & Head
Department of Veterinary & Animal Husbandry Extension Education
Bihar Veterinary College
Bihar Animal Sciences University (BASU), Patna.

Dr. Mritunjay Kumar
Associate Professor
Department of Veterinary Medicine
Bihar Veterinary College
Bihar Animal Sciences University (BASU), Patna.

Course Conveners
Dr. Y. S. Jadoun
Associate Professor & Head
Department of Diary Extension Education
Sanjay Gandhi Institute of Diary Technology (SGIDT)
Bihar Animal Sciences University (BASU), Patna.

Dr. Gyandev Singh
Assistant Professor
Department of Veterinary Surgery & Radiology
Bihar Veterinary College
Bihar Animal Sciences University (BASU), Patna.

Course Coordinators
Dr. Puspendra Kumar Singh
Assistant Professor
Department of Veterinary & Animal Husbandry Extension Education
Bihar Veterinary College, Bihar Animal Sciences University (BASU), Patna.

Dr. Ankesh Kumar
Associate Professor
Department of Veterinary Gynaecology & Obstetrics
Bihar Veterinary College, Bihar Animal Sciences University (BASU), Patna.

बिहार पशु विज्ञान विश्वविद्यालय
BIHAR ANIMAL SCIENCES UNIVERSITY

BIHAR ANIMAL SCIENCES UNIVERSITY
BIHAR VETERINARY COLLEGE CAMPUS, PATNA- 800014
Directorate of Extension Education

Dr. Umesh Singh
Director Extension Education

Ph. No. : 0612-2227261 Email: deebasupatna@gmail.com

Message

It gives me immense pleasure to present this training manual entitled **Hands-on Training on "Advanced Diagnostic and Therapeutic Techniques in Veterinary Practices"** prepared for the veterinary officers of Bihar. This manual is a part of the university's ongoing commitment to strengthening the field-level capacities of veterinary professionals through skill-based, practical training aligned with the current demands of animal health and production systems.

There has been significant advancements in recent years, particularly in the domains of diagnostics, therapeutics, and disease management. The livestock sector in Bihar plays a crucial role in ensuring nutritional security and rural livelihoods. Therefore, it is imperative that our veterinary officers are well-equipped with the latest techniques, tools, and approaches in clinical diagnosis and treatment. This training program is specifically designed to provide **hands-on exposure to advanced diagnostic procedures, clinical interpretation, therapeutic interventions, and critical care protocols** relevant to field conditions.

This manual will serve as both a **training guide and a practical reference**, enabling officers to enhance their professional competence and offer improved veterinary services to farmers. The content has been thoughtfully curated by experienced faculty members and domain experts of Bihar Animal Sciences University, keeping in mind the real-world challenges faced in rural veterinary practice.

I extend my sincere appreciation to the organizing team, resource persons, and contributors who have worked diligently to develop this valuable resource. I am confident that the training, along with this manual, will significantly enhance the clinical acumen of our veterinary officers and contribute meaningfully to the health and productivity of livestock in Bihar.

I wish all the participants a fruitful and enriching training experience.

Dr. Umesh Singh
DEE, BASU, Patna

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Extension Activities of Directorate of Extension Education BASU, Patna

Y.S. Jadoun, Umesh Singh and A.K. Thakur
Directorate of Extension Education (DEE)
Bihar Animal Sciences University (BASU), Patna

The **Directorate of Extension Education (DEE)** at **Bihar Animal Sciences University (BASU), Patna**, serves as a vital bridge connecting cutting-edge research and innovations developed within the university to the practical needs of farmers across Bihar. Its core mandate is to facilitate the **transfer of scientific knowledge and proven technologies** related to animal husbandry and veterinary sciences directly to livestock owners, rural youth, and other stakeholders involved in the livestock sector.

To fulfil this mission, the directorate undertakes a wide array of **farmer-centric extension activities**, including **capacity-building programs, on-farm demonstrations, village adoption models, mobile veterinary services, BASU Krishi Gyan Vahan, awareness campaigns, and digital outreach initiatives**. These programs are designed to promote best practices in areas such as **livestock health management, breeding, nutrition, fodder production, disease prevention**, and **value-added animal products**.

By engaging with farmers through both physical and digital platforms, the Directorate ensures that the latest innovations and scientific interventions reach the grassroots level, thereby contributing to improved productivity, better animal welfare, and enhanced rural livelihoods. The major extension activities carried out by the Directorate of Extension Education are outlined below.

Farmer Training Programs

Conducts regular **on-campus and off-campus trainings** for farmers, livestock keepers, veterinary officers, dairy field officers, livestock assistants, and rural youth. Such as:

- Dairy farming and milk processing
- Diagnostic and therapeutic techniques in veterinary practices

- Goat and poultry farming
- Fodder production and silage making
- Clean milk production
- Animal health and vaccination

Field-Level Demonstrations and Farmer Interface

a) FLDs and OFTs

Frontline Demonstrations (FLDs) and On-Farm Trials (OFTs) to evaluate and popularize livestock technologies across farming systems.

b) Demonstration Units at KVK, Jamui

Directorate of Extension Education (DEE) at **Bihar Animal Sciences University (BASU), Patna**, established the demonstration units for **goat, poultry, pig, and cattle** at the newly created KVK in Jamui, significantly enhancing experiential learning and hands-on training opportunities. Additionally, I played a key role in setting up a nursery demonstration unit, two borewells, a farm implement shed, a **Kisan Paramarsh Kendra**, and a seed production unit at KVK Jamui

c) New KVK at Jamui

Directorate of Extension Education (DEE) at **Bihar Animal Sciences University (BASU), Patna** is instrumental in establishing a new KVK, extending the university's presence and outreach in tribal and underdeveloped regions.

Animal Health and Awareness Camps: Organizes **free veterinary health camps** in remote and rural areas.

Services include:

- Vaccination
- Deworming
- Disease diagnosis and treatment
- Infertility and reproductive disorder treatments

Also conducts awareness campaigns on zoonotic diseases and hygienic livestock practices.

Farmer-Scientist Interaction Programs: Arranges interactive sessions between university experts and local farmers.

Aims to:

- Solve field-level livestock problems
- Collect feedback for research and extension improvements
- Promote collaborative learning and experience sharing

Collaboration and Networking

Directorate of Extension Education, Bihar Animal Sciences University (BASU), Patna have strong collaboration, linkages and networking with

- BAMETI
- Animal and Fisheries Resources Department (AFRD), Bihar
- NABARD
- COMFED
- JEEViKA
- Bihar Livestock Development Agency (BLDA)
- ICAR-RCER & ICAR-ATARI
- National Commission for Women (NCW), New Delhi
- Dairy Development Department, Bihar

These linkages have facilitated joint training programs, funding, innovation dissemination, and field demonstrations.

Information, Education, and Communication (IEC) Activities

Publication and Distribution of Extension Literature

Publishes leaflets, booklets, manuals, and newsletters in regional languages for easy understanding.

Topics include disease management, fodder production, breeding techniques, and value-added dairy products.

Audio-Visual Aids

Produces educational videos and slide presentations on animal husbandry practices.

Broadcasts programs through Doordarshan, All India Radio, and local cable

networks.

Use of ICT Tools

Provides information through mobile apps, SMS services, and WhatsApp groups.
Maintains an online knowledge updates on livestock management at University website

Organization of Exhibitions, Fairs, and Events;
Livestock and Agriculture Fairs (Pashu Melas)

- Hosts exhibitions to showcase latest technologies, breeds, and innovations.
- Offers platform for farmers to interact with scientists and companies.

World Veterinary Day, World Milk Day, and Other Celebrations

- Organizes events to spread awareness on livestock health, nutrition, and productivity.
- Involves school children, farmers, and stakeholders for community participation.

Participation in State/National Exhibitions

- Represents BASU in regional and national agri expos and fairs.
- Demonstrates university innovations and farmer success stories.

Flagship Programs and Initiatives Directorate of Extension Education

Directorate of Extension Education (DEE) at **Bihar Animal Sciences University (BASU), Patna**, implemented numerous innovative extension programs aimed at bridging the gap between research and client system of livestock farmers of the state.

a) Cattle Expo-2023

Organized Bihar's landmark Cattle Expo, promoting livestock technologies, breed improvement, and farmer-scientist interaction.

b) Pashupalan Darshika – Hindi Magazine

Launched Quarterly Hindi Magazine **'Pashupalan Darshika'**, a monthly

publication in Hindi to disseminate livestock-related knowledge tailored to Bihar's rural population.

c) e-Kisan Samadhan

A digital initiative leveraging WhatsApp groups for quick advisory delivery, real-time interaction with farmers, and dissemination of weather, disease alerts.

e-Kisan Samadhan is a digital extension initiative launched by the **Directorate of Extension Education, Bihar Animal Sciences University (BASU), Patna**, designed to provide real-time, science-based livestock advisory services to farmers through modern communication tools. The program primarily operates through **WhatsApp groups**, making it easily accessible even to farmers in remote and rural areas. It leverages **live interactive webinars**, expert-led audio-visual sessions, and regular **video uploads** on dedicated platforms to disseminate practical knowledge related to **animal health care, nutrition, breeding, disease prevention, and scientific livestock management**.

Through this initiative, farmers receive timely solutions to their field-level challenges directly from veterinary and animal husbandry experts. The platform also facilitates two-way communication, allowing farmers to ask questions, share field observations, and adopt improved practices based on expert feedback. By combining digital technology with expert outreach, **e-Kisan Samadhan** plays a vital role in **empowering livestock farmers and rural youth**, enhancing productivity, and promoting sustainable livestock-based livelihoods. It stands as a model for **inclusive, ICT-driven agricultural extension**, effectively bridging the gap between research institutions and grassroots communities.

d) BASU Krishi Gyan Vahan: A Mobile Knowledge Dissemination Initiative

Bihar Animal Sciences University (BASU), Patna under my supervision as overall Nodal Officer has started a unique initiative known as the **"Krishi Gyan Vahan"**, under 4th Krishi Road Map, Govt. of Bihar, a mobile extension, and outreach service aimed at bridging the knowledge gap between researchers, extension personnel, and farmers across Bihar. This initiative plays a crucial role in technology dissemination, awareness creation, and capacity building among livestock and crop farmers,

particularly in remote and underserved regions.

The **Krishi Gyan Vahan** is a well-equipped vehicle carrying:

- Audio-visual aids (TV, PA system, projector)
- Training materials, leaflets, and brochures
- Models and samples for demonstration
- Veterinary medicines and diagnostic kits

Teams comprising **BASU scientists**, **veterinary officers**, and **subject matter specialists (SMSs)** from **KVKs** accompany the van during field visits. The Vahan follows a pre-determined schedule covering different blocks and panchayats, in collaboration with the **AFRD**, **KVKs and ATMA**, and other allied departments.

e) Village Adoption Program

Adopted Dariyapur Village of Naubatpur block Patna under a participatory rural extension model focused on dairy and poultry development, with the objective of transforming it into a model village. The initiative aimed at holistic livestock development, creating a cascading impact in nearby areas by enhancing income levels and generating employment opportunities

Conclusion

The Directorate of Extension Education, BASU Patna, is the backbone of the university's outreach efforts. Through a combination of training, awareness campaigns, field demonstrations, and collaboration, it significantly contributes to the socio-economic upliftment of farmers in Bihar. The directorate continues to evolve with technology and farmer needs, aiming to build a vibrant and self-sustaining livestock sector in the state.

Fluid Therapy in Veterinary Medicine: Principles, Practices, and Clinical Applications

Mritunjay Kumar
Department of Veterinary Medicine
Bihar Veterianry College, Patna- 800014.

Fluid therapy forms a cornerstone of veterinary clinical practice, serving as a life-saving intervention in a wide range of conditions. It is indispensable for restoring and maintaining fluid balance, correcting acid-base and electrolyte imbalances, supporting adequate tissue perfusion, and acting as a medium for delivering medications. In clinical settings, animals often present with varying degrees of dehydration or fluid shifts resulting from trauma, surgical interventions, gastrointestinal disturbances, renal dysfunction, or systemic infections. These conditions can lead to compromised circulation, shock, or multi-organ dysfunction if not managed promptly. Timely and accurate fluid administration—tailored to the type and extent of the fluid loss—is critical in stabilizing patients, improving prognosis, and expediting recovery. Whether employed in emergency resuscitation, perioperative care, or chronic disease management, fluid therapy remains one of the most frequently employed and effective tools in veterinary medicine.

Body Water Distribution and Physiology

Water is the most abundant component in an animal's body, accounting for approximately 60% of total body weight. This total body water is distributed between two primary compartments: intracellular fluid (ICF) and extracellular fluid (ECF). About two-thirds of the total water resides within cells (ICF), where it is essential for maintaining cellular metabolism and biochemical functions. The remaining one-third is located in the ECF, which is further subdivided into the interstitial fluid (three-fourths of ECF) and intravascular fluid or plasma (one-fourth of ECF). This division is critical because the fluid in the intravascular space directly influences blood volume and pressure, while the interstitial fluid serves as the medium through which nutrients, waste products, and gases are exchanged between the blood and cells. Fluid movement between these compartments occurs freely due to the permeability of cell and capillary membranes to water. However, the movement is primarily governed by osmotic gradients created by solute concentrations, particularly electrolytes and plasma proteins. Osmotic pressure and hydrostatic pressure are key forces that regulate fluid exchange, ensuring equilibrium across compartments. Understanding this distribution is crucial in veterinary fluid therapy, as it guides appropriate fluid

selection and volume replacement strategies for restoring physiological balance.

Indications for Fluid Therapy

- Correction of dehydration and hypovolemia
- Management of acid-base and electrolyte imbalances
- Supportive therapy for renal dysfunction
- Drug delivery via constant-rate infusions (CRI)
- Maintenance during perioperative periods
- Inducing diuresis in cases of toxicosis

Types and Classification of Dehydration

Dehydration refers to the loss of body water along with essential electrolytes, resulting in an imbalance in the fluid compartments of the body. It is a common clinical condition encountered in veterinary practice, often secondary to gastrointestinal diseases, renal dysfunction, or systemic illness. Based on the relative loss of water and electrolytes, dehydration is broadly classified into three types: isotonic, hypotonic, and hypertonic. Each type has distinct pathophysiological features and requires tailored fluid therapy for effective correction.

Isotonic Dehydration

This is the most encountered form of dehydration in animals. It involves a proportional loss of water and electrolytes, primarily sodium and chloride, resulting in no significant change in plasma osmolality. Common causes include vomiting, diarrhea, polyuria, and hemorrhage. Because the osmotic balance between intracellular and extracellular compartments remains unchanged, water does not shift significantly between them. However, the loss of extracellular fluid (ECF) volume can compromise perfusion, leading to signs such as decreased skin turgor, prolonged capillary refill time (CRT), dry mucous membranes, and tachycardia. Isotonic crystalloid solutions like Lactated Ringer's Solution or Normal Saline are typically used to correct this type of dehydration.

Hypotonic Dehydration

In hypotonic dehydration, the loss of electrolytes, especially sodium, exceeds the loss of water. This results in decreased plasma osmolality, leading to a net movement of water from the extracellular space into the intracellular space, causing cellular swelling. This condition is commonly seen in cases of secretory diarrhea caused by pathogens like Escherichia coli or Salmonella, as well as in conditions such as pyloric stenosis and gastric dilatation-volvulus. Clinical signs may include lethargy, muscle

weakness, and in severe cases, neurological manifestations due to cerebral edema. Treatment involves administering isotonic or mildly hypertonic fluids, often supplemented with sodium, to restore osmotic balance and correct the deficit.

Hypertonic Dehydration

This type results from a greater loss of water than electrolytes, causing increased plasma osmolality. Water shifts from the intracellular to the extracellular space in an attempt to restore osmotic balance, leading to cellular dehydration. Conditions such as diabetes insipidus, inadequate water intake, and excessive panting or fever commonly cause hypertonic dehydration. Affected animals may exhibit marked thirst, dry mucous membranes, and signs of neurological dysfunction like ataxia and seizures. Rapid correction with hypotonic fluids should be avoided due to the risk of cerebral edema; instead, gradual rehydration using isotonic or slightly hypotonic solutions is preferred.

Clinical Signs

Recognizing the clinical signs of dehydration is critical for timely diagnosis and appropriate fluid therapy. Dehydration in animals is assessed by estimating the percentage of total body water lost, with severity ranging from mild and subclinical to life-threatening. When dehydration is less than 5%, clinical signs are often absent or very subtle, making it difficult to detect without laboratory testing. At 5–6%, signs such as tacky (sticky) mucous membranes and a slight delay in skin tenting may be observed, indicating mild dehydration. Moderate dehydration (7–8%) is characterized by more obvious clinical signs, including dry mucous membranes, sunken eyes, prolonged capillary refill time (CRT of 2–3 seconds), and decreased skin elasticity. In severe cases (10–12%), signs include markedly sunken eyes, cold extremities, CRT exceeding 3 seconds, severe skin tenting, and signs of circulatory collapse or early shock. Dehydration exceeding 12–15% is critical and often results in hypovolemic shock, collapse, and death if not immediately corrected. Consistent evaluation of mucous membrane moisture, CRT, skin turgor, eye position, and general demeanor is essential in assessing dehydration severity and guiding fluid therapy.

Diagnostic Evaluation

- Laboratory values aid in diagnosing and grading dehydration:
- PCV & Total Protein: Increased in dehydration
- Serum electrolytes: Guide specific replacement therapy
- BUN/Creatinine: Elevated in pre-renal azotemia

- USG (Urine SG): >1.030 suggests renal response to dehydration

Types of Fluids

Fluid therapy in veterinary medicine relies on two major categories of fluids: crystalloids and colloids. The choice depends on the type and severity of dehydration, the underlying disease condition, and the therapeutic goal, whether it is volume expansion, maintenance, or correction of electrolyte or acid-base imbalances.

A. Crystalloids

Crystalloids are water-based solutions containing small molecules such as electrolytes and sugars that can easily cross capillary membranes. They are the most used fluids in veterinary practice due to their affordability and broad applicability.

1.IsotonicCrystalloids

These solutions have osmolality similar to plasma and are ideal for rehydration, electrolyte correction, and general fluid replacement.

0.9% Normal Saline (NaCl): Sodium-rich; lacks potassium and calcium. Used in cases of vomiting, diarrhea, and metabolic alkalosis.

Lactated Ringer's Solution (LRS): Contains sodium, potassium, calcium, chloride, and lactate (a buffer). Suitable for treating metabolic acidosis and general fluid loss.

Ringer's Solution: Similar to LRS but without lactate; preferred in large animals that are prone to alkalosis.

Normosol-R and Plasmalyte: Balanced electrolyte solutions; good for perioperative and critical care patients.

Dosage (dogs/cats/cattle)

Maintenance: 40–60 ml/kg/day

Replacement: Depends on % dehydration (e.g., 10% dehydration in a 25 kg dog = 2500 ml over 24 hrs)

Shock Dose: Dogs – up to 90 ml/kg/hr; Cats – 50–60 ml/kg/hr

2. Hypotonic Crystalloids

5% Dextrose in Water (D5W): Provides free water, not suitable for volume expansion. Used to manage hypoglycemia, especially in neonates or septic patients.

3. Hypertonic Crystalloids

3–7.5% Hypertonic Saline: Draws fluid from interstitial and intracellular compartments into the vascular space. Rapidly improves blood pressure in cases of hypovolemic or endotoxic shock.

Dosage: 4–5 ml/kg IV over 5–10 minutes (dogs, cattle); must be followed by isotonic crystalloids to maintain fluid balance.

B. Colloids

Colloids are fluids containing large molecules that remain within the vascular compartment, making them ideal for maintaining oncotic pressure and plasma volume in hypoproteinemic or hypotensive animals.

1. Natural Colloids

Whole Blood: Used in hemorrhagic shock or severe anemia.
Plasma: Corrects hypoproteinemia and coagulopathies.
Packed RBCs: Indicated in anemic but normovolemic animals.
Dosage:
Whole Blood: 10–20 ml/kg IV
Plasma: 10–15 ml/kg IV
Packed RBCs: 1 unit/10–20 kg body weight

2. Synthetic Colloids

Hetastarch (e.g., Vetplasma), Dextrans: Effective in maintaining blood pressure during shock and severe hypoalbuminemia. They provide rapid plasma volume expansion and are often used in combination with crystalloids.

Dosage

Dogs: 5–10 ml/kg IV over 15–30 minutes
Cattle: 8–10 ml/kg IV
Small animals: 10–20 ml/kg/day, adjusted based on CVP and hydration status

In all cases, fluid therapy must be carefully monitored to prevent complications like fluid overload, pulmonary edema, or electrolyte disturbances. Regular reassessment of clinical and laboratory parameters is vital for ensuring safe and effective treatment. Choosing the appropriate fluid type is a critical step in effective fluid therapy, as it directly impacts the correction of underlying physiological disturbances. The decision should be based on a thorough clinical assessment of the animal, supported by laboratory data. Several factors must be considered, including the type and extent of fluid loss, electrolyte imbalances, acid-base status, and the specific pathophysiology of the disease involved.

Fluid Selection Based on Clinical Condition

The nature of fluid loss, whether isotonic, hypotonic, or hypertonic—plays a central role in fluid selection. For isotonic dehydration, isotonic crystalloids such as Lactated Ringer's Solution (LRS) or Normal Saline (0.9% NaCl) are typically used. In cases of

acidosis, LRS is preferred due to its lactate content, which serves as a buffer and is converted into bicarbonate by the liver. Conversely, in patients with metabolic alkalosis, Ringer's Solution (which lacks lactate) is more suitable, particularly in large animals prone to alkalosis. Hypertonic saline is used in emergency situations such as shock to rapidly expand plasma volume, but it must be followed by isotonic fluids to prevent rebound dehydration.

Electrolyte-Based Fluid Modification

Electrolyte supplementation is often necessary to tailor the fluid therapy to the patient's needs.

Potassium (K^+): Hypokalemia is defined as serum K^+ levels below 3.5 mEq/L and is commonly associated with prolonged anorexia, diarrhea, or diuretic use. Potassium chloride can be added to fluids cautiously (not exceeding 0.5 mEq/kg/hr) to correct the deficit.

Bicarbonate (HCO_3^-): Indicated in metabolic acidosis, often seen in severe diarrhea or renal failure. The bicarbonate requirement is calculated using the base deficit **formula:**

HCO_3^- needed (mEq) = Base Deficit × 0.3 × Body Weight (kg).

Overcorrection should be avoided as it may lead to alkalosis and neurologic complications.

Dextrose: Used in cases of hypoglycemia, liver disease, sepsis, or neonatal weakness. A 5% dextrose solution can maintain normoglycemia, while 50% dextrose diluted appropriately is used for acute correction.

Calcium (Ca^{2+}): Hypocalcemia may occur in parturient paresis or sepsis. Calcium gluconate is commonly administered slowly IV while monitoring cardiac function.

Appropriate fluid selection and supplementation not only restore fluid balance but also correct metabolic derangements, support organ function, and improve clinical outcomes. Regular monitoring of clinical signs, urine output, and laboratory values is essential for adjusting the therapy accordingly.

Routes of Administration

IV: Preferred (jugular, cephalic, saphenous)
Intraosseous: For neonates, rapid access
Intraperitoneal: For young animals (slow absorption)
Subcutaneous: Only for mild dehydration (avoid 5% dextrose)

Fluid Calculation and Therapy Plan

Formula:

Fluid required (ml) = {Body weight (g) × % dehydration} + Estimated ongoing

losses + Maintenance
Maintenance requirement:
{(BW in kg × 30) + 70} ml/day
Example:
25 kg dog, 10% dehydrated = 25000 g × 0.10 = 2500 ml (deficit)
Fluid distribution:
Total Body Water (TBW) loss = 2500 ml
ECF (⅓ of TBW) = ~833 ml
IVF (¼ of ECF) = ~208 ml

Fluid Infusion Rates and Monitoring
Shock Rate (dog): Up to 90 ml/kg/hr with close CVP monitoring
General Protocol:
- 1st hr: 13-14 ml/kg/hr
- 2nd hr: 10 ml/kg/hr
- 3rd hr: 5 ml/kg/hr
- 4th hr onward: 2 ml/kg/hr

Monitor:
- Daily weight
- Lung sounds (for overload)
- CRT, urine output, CVP

Signs of Overhydration:
- Serous nasal discharge
- Crackles, restlessness
- Drop in PCV/TP, increased BP

Fluid Therapy in Specific Conditions
Fluid therapy plays a vital role in the management of various disease-specific conditions in animals by restoring and maintaining circulatory volume, correcting electrolyte and acid-base imbalances, and supporting organ function. In conditions such as shock, diarrhea, vomiting, ketosis, and renal dysfunction, timely and tailored fluid administration can be lifesaving. The type, volume, and rate of fluids must be carefully chosen based on the pathophysiology of the disease, species involved, and clinical status of the patient. Accurate fluid therapy not only improves recovery and survival rates but also enhances the effectiveness of concurrent treatments.

This table summarizes fluid therapy recommendations across various disease conditions in dogs, cats, and cattle, including appropriate fluid types and dose rates. It

is designed to aid clinical decision-making in common scenarios.

Condition	Species	Fluid Choice	Dose Rate	Notes
Ketosis	Cattle	5–10% Dextrose IV + oral propylene glycol	500–1000 ml IV over 30–60 min daily	Common post-partum; combine with energy sources
	Dogs/Cats	0.9% NaCl → 0.45% NaCl + 2.5–5% Dextrose	10–20 ml/kg/hr	For diabetic ketoacidosis (DKA)
Vomiting	Dogs/Cats	LRS or 0.9% NaCl + KCl	Maintenance + deficits + ongoing loss	Monitor electrolytes, esp. K^+
	Cattle	0.9% NaCl ± KCl ± Calcium	40–80 ml/kg IV	Often metabolic alkalosis due to reflux
Diarrhea	Dogs/Cats	LRS + KCl ± bicarbonate	Based on % dehydration + losses	Commonly causes metabolic acidosis
	Calves	Oral fluids (mild), IV isotonic bicarbonate or LRS + glucose	80–100 ml/kg IV over 4–6 hr	Assess acidosis; add glucose for energy
Cerebral Edema	Dogs/Cats	Hypertonic saline (3%) or Mannitol	4–5 ml/kg hypertonic saline or 1–2 g/kg Mannitol IV	Avoid hypotonic fluids (e.g., D5W)
Meningitis	Dogs/Cats	Isotonic crystalloids (LRS, Normosol-R)	40–60 ml/kg/day (maintenance)	Monitor neurologic status
	Calves	LRS + glucose + antibiotics	60–100 ml/kg IV over 6–8 hr	Supportive + antimicrobial therapy
Fever	Dogs/Cats	LRS or Plasmalyte	Maintenance + 10–20% extra per °C rise	Compensate for insensible fluid loss
	Cattle	Ringer's or Normal saline	Add 4.5–5 L/day per 1°F (0.55°C) temp increase	Adjust total fluid intake accordingly
Jaundice	Dogs/Cats	LRS or 0.9% NaCl (avoid lactate in severe liver dysfunction)	Maintenance rate (40–60 ml/kg/day)	Supportive; monitor liver enzymes and hydration
Hepatitis	Dogs/Cats	0.9% NaCl ± glucose ± potassium	Maintenance + correction of deficits	Avoid lactate-containing fluids in severe hepatic disease
Renal Failure (Acute)	Dogs/Cats	0.9% NaCl, Plasmalyte, Normosol-R	60–90 ml/kg/day or based on urine output	Monitor BUN, creatinine, and electrolytes closely
Renal Failure (Chronic)	Dogs/Cats	Subcutaneous LRS or Normosol-R	10–20 ml/kg/day SC	Used for long-term maintenance at home
Ascites	Dogs/Cats	0.9% NaCl ± colloids (Hetastarch)	Maintenance only, avoid aggressive boluses	Cautious use to prevent worsening effusion
Congestive Heart Failure	Dogs/Cats	Restricted fluids, low sodium (¼ strength saline)	2–4 ml/kg/hr IV or < maintenance	Monitor for pulmonary edema; avoid overload
Anemia	Dogs/Cats	Whole blood or packed RBCs	10–20 ml/kg IV over 1–2 hrs	Corrects oxygen-carrying capacity in severe cases
Pancreatitis	Dogs/Cats	LRS or Normosol-R + KCl	Maintenance + ongoing loss (60–90 ml/kg/day)	Avoid fatty emulsions; correct electrolyte losses

Conclusion

Fluid therapy is an indispensable tool in veterinary clinical practice, providing critical support in a wide range of disease conditions—from dehydration, shock, and renal failure to systemic infections, hepatic dysfunction, and cardiac disorders. Its

effectiveness lies in the accurate assessment of fluid deficits, electrolyte imbalances, and the underlying pathophysiology of the disease. Tailoring fluid type, volume, and administration route to the specific needs of each patient-whether a calf with diarrhea, a cat with renal disease, or a dog with pancreatitis-ensures optimal therapeutic outcomes. Close monitoring during therapy, including hydration status, urine output, cardiovascular and respiratory parameters, is essential to prevent complications such as fluid overload or electrolyte disturbances. Mastery of fluid therapy principles significantly improves survival, accelerates recovery, and enhances the overall standard of veterinary care.

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Blood Transfusion in Veterinary Practice: A Comparative Overview for Ruminants and Companion Animals

Mritunjay Kumar and Anil Kumar
Department of Veterinary Medicine
Bihar Veterianry College, Patna- 800014.

Blood transfusion is a critical therapeutic intervention in both large and small animal veterinary practice. It involves the administration of whole blood or blood components from a donor to a recipient animal to restore circulatory volume, improve oxygen-carrying capacity, or correct coagulation abnormalities. The application of transfusion has expanded with better understanding of species-specific blood types, transfusion techniques, and blood component therapies. In ruminants such as cattle, sheep, and goats, transfusions are mainly used in acute hemorrhage or parasitic anemia, while in companion animals like dogs and cats, the indications are more diverse and frequently encountered in clinical practice.

Blood Groups in Animals

Each species has distinct blood group systems which are crucial in avoiding transfusion reactions. Cattle have 11 blood group systems with complex polymorphisms; the B system is highly antigenic. Sheep and goats also have several group systems, though their clinical relevance is less defined. Dogs have more than a dozen blood group systems, most notably the Dog Erythrocyte Antigen (DEA) system, where DEA 1.1 is most significant for transfusion compatibility. Cats have three blood types: A, B, and AB. Naturally occurring alloantibodies in cats mean that unmatched transfusions can be fatal, making typing essential even before the first transfusion.

Indications for Transfusion

Blood transfusions are indicated in a variety of clinical conditions. In cattle, sheep, and goats, the primary indications include acute blood loss due to trauma or surgery, parasitic anemia (e.g., Haemonchosis), and coagulopathies. In small animals, indications extend to immune-mediated hemolytic anemia (IMHA), rodenticide poisoning, thrombocytopenia, disseminated intravascular coagulation (DIC), and hypoalbuminemia. Fresh whole blood, packed red blood cells (pRBCs), plasma, and platelet-rich plasma are used according to the specific need of the patient.

Materials Required

Blood transfusion requires appropriate materials for safe collection, storage, and administration:

- Blood bags with anticoagulants (e.g., CPDA)
- Blood administration sets with filters (BT set)
- Sterile syringes and needles
- Centrifuge for component separation
- Cross-matching and typing kits
- Refrigerators and freezers for storage

Donor and Recipient Selection

Ideal donors are healthy, adequately vaccinated, and free of infectious diseases. In cattle and small ruminants, herd members are usually selected. A bovine donor can safely give up to 10–15 mL/kg body weight. Dogs weighing over 25 kg and cats over 4.5 kg are typically used as donors. Donors must be screened for diseases like Babesiosis, Anaplasmosis, Ehrlichiosis in dogs, and FeLV/FIV in cats. Recipients must be clinically evaluated for the need based on PCV, clinical signs, and hemodynamic parameters.

Compatibility Testing

Cross-matching is a laboratory procedure performed before blood transfusion to ensure compatibility between donor and recipient animals. It is aimed at preventing potentially fatal immunologic transfusion reactions due to blood group incompatibilities. Cross-matching detects the presence of naturally occurring or acquired antibodies that may cause hemolysis or agglutination of red blood cells (RBCs).

Types of Cross-Match

1. Major Cross-Match:

- Tests recipient's serum (antibodies) against donor's RBCs**.**
- Critical for detecting antibodies in the recipient that may attack donor RBCs.
- Essential in all species**,** especially cats and previously transfused dogs.

2. Minor Cross-Match:

- Tests donor's serum against recipient's RBCs**.**
- Detects antibodies in donor plasma that might react with the recipient's RBCs.
- Less critical in dogs, where donor plasma is often diluted or removed (packed RBCs used).

Materials Required

- Fresh blood samples from donor and recipient**:**

- EDTA tube (for RBCs)
- Plain tube (for serum)
- Centrifuge
- Microscope slides and cover slips
- Normal saline (0.9% NaCl)
- Test tubes (preferably labeled)
- Water bath (37°C)
- Light microscope
- Pipettes or droppers

Step-by-Step Cross-Matching Procedure

1. Sample Preparation

- Collect 2–3 mL of blood from both donor and recipient:
- Separate serum by centrifuging clotted samples at 1500 rpm for 10 minutes.
- Wash RBCs from EDTA blood 3–4 times in normal saline by centrifugation (1500 rpm for 2–3 minutes).
- After final wash, make a 2–5% RBC suspension in saline.

2. Major Cross-Match

Mix:

- 2 drops of recipient serum
- with 1 drop of donor RBC suspension
- Incubate at 37°C for 15–30 minutes.

Examine:

- Macroscopically for hemolysis or agglutination.
- Microscopically under 10x or 40x for RBC clumping (agglutination).

3. Minor Cross-Match

Mix:

- 2 drops of donor serum
- with 1 drop of recipient RBC suspension
- Follow same incubation and examination steps.

4. Control Tubes (Optional but Recommended)

To validate results and rule out nonspecific reactions:

- Auto-control**:** Mix recipient serum with recipient RBCs.
- Saline control**:** Mix saline with RBC suspension (ensures no spontaneous agglutination).

Interpretation of Results

Finding	Interpretation	Action
No hemolysis or agglutination	Compatible	Safe to transfuse
Hemolysis or agglutination in major	Incompatible	Do not use donor

Important Species-Specific Notes

Cats: Have naturally occurring alloantibodies. Cross-match always, even for the first transfusion.

Dogs: First transfusion may be safe without cross-match, but must cross-match for subsequent transfusions or unknown history.

Ruminants: May tolerate first mismatched transfusion; however, cross-matching is ideal, especially for valuable animals or repeat transfusions.

Procedure of Blood Collection and Transfusion

Blood is collected aseptically from the jugular vein using anticoagulant-containing bags. It should be gently agitated during collection. For transfusion, blood is warmed to room temperature and administered intravenously via a filter. The rate starts at 0.5–1 mL/kg/hr for the first 15 minutes to monitor for reactions, then increased up to 10 mL/kg/hr. Total transfusion volume should not exceed 20 mL/kg per session and be completed within four hours.

Benefits of Transfusion

Transfusion provides immediate physiological benefits:

- Restores oxygen-carrying capacity (RBCs)
- Replenishes clotting factors (plasma)
- Corrects thrombocytopenia (PRP)
- Maintains oncotic pressure (albumin)

In ruminants, it significantly improves survival in periparturient hemorrhage and parasitic anemia. In small animals, targeted component therapy reduces the risk of volume overload and improves clinical outcomes in IMHA, DIC, and surgical interventions.

Adverse Reactions and Their Management

Adverse transfusion reactions include:

- Hemolytic reactions: due to mismatched blood
- Febrile non-hemolytic reactions
- Allergic reactions: urticaria, vomiting
- Anaphylaxis
- Infectious disease transmission

• Hypocalcemia due to citrate toxicity

To avoid these, use typed and cross-matched blood, start transfusions slowly, monitor continuously, and use appropriate filters. Corticosteroids or antihistamines may be pre-administered in at-risk patients.

Conclusion

Blood transfusion and component therapy are vital tools in veterinary care for both food-producing and companion animals. The success of transfusion depends on species-specific knowledge, appropriate donor and recipient selection, and careful monitoring. With advancements in transfusion medicine and better access to diagnostic tools, veterinarians can save lives with safer and more effective transfusion protocols.

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Orthopedic, Soft Tissue and Emergency Surgeries

Aakanksha and Rajesh Kumar
Department of Veterinary Surgery and Radiology
Bihar Veterianry College, Patna- 800014.

Orthopedic Surgeries

Fracture

A complete or incomplete break in the continuity of bone or cartilage or both is called fracture. These are mainly related to extrinsic factors of various types of direct or indirect trauma and the forces that may act on a bone or intrinsic factors like muscle contraction, pathological fracture or repeated stress. The symptoms include deformity, loss of function, abnormal mobility, pain and crepitus. During fracture repair recognition, reduction (closed/open), retention and rehabilitation should be considered. Direct or primary bone healing occurs without callus formation. Indirect or secondary bone healing occurs with a callus precursor stage including stage of haematoma, callus formation and stage of remodeling. However, complications like delayed union, non-union or mal-union may also occur.

External coaptation

External coaptation is defined as limb splinting that aid in stability & support of soft tissue and hard tissue. It serves as temporary support, first aid, secondary support after surgical intervention or primarily support and stabilization of fracture fragments. Minimum displaced fracture is suitable for EC. Reduction of fracture fragments must be achieve before application. Proper joint alignment is necessary to avoid malunion. Failure of align the major bone fragment with respect of joint can lead to malunion. Splint, bandage or cast should be applied so that the limb is maintained in a neutral standing position**.** Joint above and below must be immobilized. Most conventional splint and cast are adequate for fracture below and elbow and stifle joint. Selecting appropriate EC should be on the basis of patient and environment factor. If severe soft tissue inflammation is expected a temporary well-padded splint is beneficial.

· **Robert Jone bandages:** Bandage extend from toe to mid humerus or mid femur and provide temporary support of fracture or dislocation at or below the elbow or stifle joint. A tape stirrup is applied to medial and lateral surface of leg. A roll of

cotton is wrapped loosely to give padding and compressed with elastic gauze to provide stiffness & compression. Stirrup are inverted & bandage is covered with elastic tape.

· **Light or modified Robert jone bandage:** less cotton padding is used. It is not suitable for temporary support but used after internal fixation to reduce swelling of the soft joint.

· **Reinforced Robert Jone bandage:** rigid material is applied to enhance immobilization of joint in light or modified Robert jone bandage.

· **Plaster of paris:** Roll of muslin stiffen with dextrose or starch impregnated with hemi hydrated Ca- phosphate can be easily and accurately moulded to contour of the limb. After reduction and application of antiseptic powder (boric acid/ sulphate powder), one or two layer of roll bandage are placed followed by uniform rolling of cotton and reapplication of bandage. Pop is immersed in water until bubbling or air stop & squeezed to remove excess water & rolled over bandage. It is left for few minute for solidification. Plaster or bandage should be applied spirally from top to bottom or vice versa. Turn of plaster bandage should overalp 50% with previous turn of its width. Each layer should be smoothened with hand provide good bound with preceding layer. At joint plaster applied in the figure of eight fashion to prevent break of plaster or prevent slipping. After final application of cast surface should be rubbed with hand to provide smooth and hard coating. However, it is heavy, has slow setting time, causes uneven pressure, so interfere with the circulation & may cause swelling.

· **Fiber glass cast:** It is light weight, harden quickly. Application is similar of POP cast.

· **Velpeau Sling:** Commonly used for immobilization of shouldher joint. It primary or help the stabilization of shouldher luxation, bicipital bursitis, minor fracture of scapula & humerus. It maintains the carpus, elbow & shoulder into flexed position & prevent weight bearing in the forelimb.

· **Ehmer sling:** Used to prevent weight bearing of the pelvic limb & maintain limited degree of hip rotation & abduction of limb.

· **Hobbles:** Circumferential tape strip constructed to allow weight bearing & walking to the hind limb, but prevent abduction of the limb at different levels.

Internal fixation technique

· **Intramedullary pinning:** Pin can be placed either by closed or open method. During open reduction strict aseptic condition should be maintained. Frequent irrigation with warm saline or ringer solution help in removal micro-organism & debris & also promote healing. After exposure of fracture side pin is inserted either in normograde or retrograde manner. Bone is anatomically reduced & pin is driven upto metaphysis of distal fragments.

· **Cross pinning:** applied for fracture closed to joint. The fracture fragments are exposed & brought into apposition & cross pinning is performed.

· **Orthopaedic wire:** In full circlage wiring a 360 degree circumferential wire is placed around a bone at the fracture site. Its use is generally restricted to the long oblique diaphyseal fracture of bone, where the length the fracture is greater than twice of diameter of bone at fracture site, for interfragmentry compression. If the length of fracture is less than twice of the diameter shearing force will be produced which will disrupt the fracture. In hemicerclage wire is placed through the bone rather than around the fracture fragments of bone.

· **Tension band wires:** Applied to convert distractive force into compression force at the tension side of the fracture. It is indicated mainly for avulsion fracture like greater trochanter of femur, tibial tuberosity, patella etc when a fragments is distracted from its original position by the pull of muscle or tendon or ligament.

· **Bone plating:** It is internal splint that hold fracture fragment of bone together. Bone plate are attached with bone by the screw. Dynamic compression plate is providing fine bone contact between fracture fragment. It provides absolute stability & allow primary bone healing. The screw hole is oval & so head slide down the slope to lower end of hole, when it is tightening. In limited contact plate under surface contact plate under surface of the plate is scalloped, so that area of plate that make contact with bone is reduced. Reconstruction plate is V shaped plate contoured in all direction, mainly used in maxilla, mandible & pelvis**.**

External Skeletal Fixation

Used for stabilization of bone fragment with percutaneous pin held together with an external frame. Advantage of ESF include early return to function of affected limb with excellent mechanical properties, ability to adjust the frame after bone fixation, avoidance of surgical trauma, so as to preserve the local blood flow at the fracture

site, avoidance of infection associated with implant, preservation of bone stimulatory protein that exude into the fracture site at the time of initial injury & provision of natural healing, easy implant removal and preservation of joint range motion.

ESF is applied under regional or general anaesthesia. After site preparation for aseptic surgery, proposed site of pin insertion is marked. A proper size of pin diameter is selected for ESF application. A small hole is predrilled at the chosen site and pin is inserted with slow speed. It is important to continuously flush with saline water while drilling pin at the insertion site. Pins are inserted in far-near-near far pattern. The pins generally placed no closer than three times diameter or half of the diameter of the bone from joints & fracture edges. Central pin should not contact fracture edge to avoid the interference with callus formation. Pin diameter no longer than 20% to 30% of the diameter of bone. The ESF can be linear or circular. With circular ESF technique, frame consist of ring connected with threaded rods. The frame is fixed to bone with tensioned small diameter wires.

Dislocation

Dislocation is defined as complete displacement of articular ends of bones when there is only a slight change in relationship of articular surface of bones is called partial dislocation or subluxation. The pain due to dislocation is constant, the tenderness is less intense and more diffuse. In dislocation there is rocking noise. A dislocation once reduced has very little tendency to re-occur provided rest is given.

Soft Tissue Surgeries

Castration

Indications: Neutering may be used in an attempt to treat certain forms of aggression, such as inter-male aggression. In older dogs, the operation may be performed to treat testicular tumors and some prostate gland conditions. It is also used to control hormonal (testosterone-dependent) diseases such as perianal adenomas.

Site of operation:

1. Pre-scrotal site: 3 cm long incision on the midline in front of the scrotum.

2. Scrotal site:

A. Longitudinal incision on the ventral aspect of scrotum lateral & parallel to median raphe on either side.

B. Similar incision on one scrotum to remove testes of that side and then a second incision (through the first) on the mediastinum testes to remove the other testicle.

Anaesthetic techniques: General anaesthesia

Control: Dorsal recumbency

Surgical Procedure:
One testes is pushed forward (in case of pre-scrotal incision) or toward (in case of scrotal incision) and is held in position by left index finger and thumb and about 2-3 cm long incision is made in the skin.

The testicle is continuously pushed outwards and gentle incisions are made in the subcutaneous fascia till shiny white tunica vaginalis is visible.
The testicle is now squeezed out and can be removed by any of the following methods:

Open method:
- An incision is given in the tunica vaginalis longitudinally over the spermatic cord.
- The anterior and posterior bundles of spermatic cord are identified.
- The testicular artery and vein are ligated with a non-absorbable suture proximal to the pampiniform plexuses. One end of the ligature is left long and held with artery forceps.
- The ductus deferens may be ligated separately and cut with a scissors.
- Artery forceps is now placed distal to the ligature in testicular vessels and the cord is cut between then. The testicle is now removed out along with artery forceps.
- The hemorrhage is checked carefully and only then the ligature end is cut short and the stump is allowed to recede in vaginal ring.

Close method:
- No incision is given in tunica vaginalis. It is ligated as such closed to the vaginal ring and is transected taking similar care for any hemorrhage as described in open method.
- The contra lateral testicle may be similarly removed after pushing it through the same incision (by making an additional incision in scrotal septum) or by making another incision in the contra lateral sac of scrotum or in case of pre-scrotal incision by incising only the contra lateral spermatic fascia.
- In cases of prescrotal incision, the skin wound is closed routinely, however in cases of scrotal incisions, these may be left open.

Post-operative care: Routine ASD and antibiotic therapy and prevention of self-mutilation.

Ovariohysterectomy

Indications: birth control programme**,** neoplasm involving ovary and uterus**,**

ovarian cyst**,** uterine diseases (pyometra, metritis, chronic endometrial hyperplasia, prolapse)**,** minimize the risk of mammary gland tumors**,** vaginal edema**,** prevention of hormonal changes that interferes with therapy for dermatitis, diabetes or epilepsy etc. are the indications of performing OHE in a bitch.

Site of operation: Ventral midline abdominal incision starting from the point of umbilicus backward over a length of 6 to 8 cm

Age and time: Best performed either before puberty or during anestrus. Six to eight months of age is generally considered best. Surgery may be most hazardous during estrus or pregnancy and in old obese females. Most suitable time to spay an adult bitch is three to four months after estrus. After whelping the operation should be done about six to eight weeks, as soon as the puppies have weaned and lactation has ceased

Control and anaesthesia: The animal is controlled in dorsal recumbency under general anaesthesia.

Surgical procedure

- A 8-10 cm long incision is given on midline from umbilicus and extending caudally. Skin, subcutaneous tissue, linea alba and peritoneum are incised to enter the abdominal cavity.
- An index finger is passed to locate the uterine horns. The uterus and ovaries are recognized and grasped with sterile gauge.
- The ovary is grasped between thumb and index finger and withdrawn for ligation. Application of artery forceps helps in efficient ligation.
- Chromic catgut is used to place a ligature over ovarian pedicle. The attachment between ovary and ligature is severed. Hemorrhage should be checked carefully.
- Similar procedure is followed to remove other ovary.
- The body of uterus is removed from abdomen after severing broad ligament. Uterine vessels are ligated. Then uterus is severed after placing double transfixing ligature.
- Uterine stump is checked carefully for hemorrhage. Abdominal incision is closed as usual.

Post-operative care

The site of operation should be checked for swelling or discharge. Course of antibiotics should be given. Antiseptic dressing is done daily. Restrict exercise for two weeks. Skin sutures are removed after 8-10 days of operation or after complete healing.

Emergency Surgeries

Emergency surgical situations in veterinary medicine require rapid diagnosis, critical decision-making, and prompt intervention. It involves procedures performed to address life-threatening conditions such as trauma, hemorrhage, obstruction, torsion, and perforation affecting vital organs. Managing surgical emergencies effectively enhances patient outcomes and minimizes mortality.

Principles of Veterinary Emergency Surgery

Veterinary emergency surgery refers to immediate surgical interventions required to save the life of an animal, relieve severe pain, or prevent irreversible organ damage. These procedures involve small animals (dogs, cats), large animals (cattle, horses), and exotic species. Indications for emergency surgery include severe trauma (vehicular accidents, falls, bites), internal haemorrhage, gastrointestinal obstruction or perforation, acute abdominal pain (acute abdomen), diaphragmatic hernia, torsion or volvulus of organs, urogenital emergencies (pyometra, obstructed urolithiasis), dystocia and uterine rupture, thoracic injuries with pneumothorax or hemothorax etc. Goal of emergency surgery is to stabilize the patient, address the primary pathology, minimize pain and distress, prevent systemic deterioration (e.g., sepsis, shock) and to preserve or restore the normal physiological function.

Initial Patient Assessment and Stabilization

Triage and Prioritization: Triage involves sorting patients based on the urgency of their condition. Categories:

- Red (Critical): Immediate life-saving intervention needed
- Yellow (Urgent): Severe but not immediately life-threatening
- Green (Delayed): Non-urgent cases
- Black: Moribund or deceased

ABCDE Approach

- A – Airway: Ensure a patent airway
- B – Breathing: Evaluate respiratory rate and pattern; administer oxygen
- C – Circulation: Check pulse, mucous membrane color, CRT; start IV fluids
- D – Disability: Assess neurological status
- E – Exposure: Examine entire body for injuries

Stabilization protocols including oxygen therapy, intravenous fluid resuscitation, analgesia and sedation, blood transfusion (if needed), correction of acid-base and electrolyte imbalances and antibiotics (broad-spectrum until culture results) are important.

Surgical Techniques in Emergencies

Asepsis and Instrumentation

Quick yet thorough preparation is essential. Surgeon can use sterile disposable kits if time is limited. The common incision techniques include midline laparotomy (most common), flank approach (ruminants) or paracostal incision (renal or adrenal access). For suturing and closure, use absorbable sutures for internal structures and non-absorbable for skin. For tension-bearing closures consider tension-relieving patterns (e.g., vertical mattress).

Anesthesia

Pre-anesthetic stabilization is critical. Use short-acting, reversible agents and monitor vital parameters continuously. The recommended protocols include premedication with opioids (morphine, methadone), induction with propofol or alfaxalone, maintenance with isoflurane or sevoflurane, and, supportive care with fluids, temperature regulation, oxygen etc. It requires additional monitoring of ECG, BP, spO_2, $ETCO_2$ and to assess the depth of anesthesia and reflexes.

Common Emergency Surgical Conditions

Species-specific emergency surgeries in small animals (dogs and cats) include GDV, dystocia, urinary obstruction, trauma etc. These conditions are often associated with high survival with prompt diagnosis and intervention. In large animals, cattle are mostly affected with uterine torsion correction, left displaced abomasum (LDA) surgery and rumenotomy for foreign body (hardware disease). The horses are mainly associated with emergency surgical procedure of colic surgery (large colon volvulus, strangulating lipoma), cesarean section (rare) or fracture fixation (limited by cost and recovery issues). Surgical options for exotic and wild animals depend on species physiology requiring individualized care. They often require sedation in traps or transport cages.

Gastrointestinal Emergencies

Gastric DilatationVolvulus (GDV)

- **Species:** Dogs (deep-chested breeds)
- **Signs:** Abdominal distension, retching, shock
- **Surgical Intervention:** Gastropexy and derotation
- **Prognosis:** Good with early intervention

Intestinal Obstruction

Causes: Foreign body, intussusception, tumors

Signs: Vomiting, anorexia, dehydration

Treatment: Enterotomy or resection and anastomosis

Rectal or Anal Prolapse
Management: Manual reduction, purse-string suture, resection if necrotic

Thoracic Emergencies
Diaphragmatic Hernia
- **Cause:** Trauma
- **Diagnosis:** Radiography
- **Surgery:** Midline laparotomy and hernia repair

Pneumothorax / Hemothorax
Procedure: Thoracocentesis, chest tube placement, surgical repair if persistent

Urogenital Emergencies
Pyometra
Common in intact female dogs
- **Treatment:** Emergency ovariohysterectomy
- **Signs:** Vaginal discharge, lethargy, PU/PD

Urethral Obstruction
Common in male cats and dogs
- **Procedure:** Perineal urethrostomy or catheterization
- **Complication:** Hyperkalemia, azotemia

Cesarean Section
- **Indications:** Dystocia, fetal distress, uterine inertia
- **Anesthetic precautions:** Minimize fetal depression

Trauma-related Emergencies
Wound Management
- **Principles:** Debridement, lavage, closure
- **Types:** Clean, contaminated, infected

Fracture Repair
- Stabilize patient first
- **Surgical options:** Internal/external fixation
- **Splenic Rupture**
- **Surgical Removal:** Splenectomy
- Monitor for hemorrhage and anemia

Postoperative Management

Intensive care is to monitor for hemorrhage, infection or dehiscence, provide analgesia (opioids, NSAIDs) and fluid therapy to maintain hydration and perfusion. Nutritional support (enteral if possible) post surgically enhances the recovery. Common complications in the post-operative period may be related to hypovolemia or shock, surgical site infection (SSI), seroma or hematoma formation, ileus or delayed gastric emptying etc. Reoperation may be required in some cases.

Ethical and Legal Considerations

Obtain informed consent from the owner explaining risks, benefits, costs, and prognosis. Document client decisions. Euthanasia can be recommended in hopeless cases or extreme suffering. Owner communication is key with humane protocols must be followed.

Pre-Surgical Preparation and Aseptic Techniques

Aakanksha and Rajesh Kumar
Department of Veterinary Surgery and Radiology
Bihar Veterinary College, Patna

Pre-surgical Preparation

Pre-surgical preparation is a multi-faceted critical process to ensure optimal outcomes for surgical interventions, requiring precision, planning, and attention to detail. It encompasses a series of standardized procedures designed to minimize surgical risks/complications, prevent infection, enhance patient safety, facilitate rapid recovery, optimize patient outcomes, and ensure the safety of both animals and veterinary personnel. Standardized protocols, individualized care plans, and vigilant monitoring throughout the perioperative period form the backbone of successful surgical practice. Effectively, it requires the understanding of animal physiology and surgical principles along with patient assessment, fasting protocols, anaesthesia planning, and aseptic techniques.

Patient Evaluation and Pre-Anaesthetic Assessment

The cornerstone of surgical preparation is a thorough evaluation of the patient's health. Signalment (species, breed, age, sex, weight) helps to predict anaesthetic risks. *Detailed history* taking including prior illnesses, medications, allergies, vaccination and deworming status, and previous anaesthetic events and *Physical examination* assessing cardiovascular, respiratory, renal, and neurologic status, as well as hydration, nutritional condition, and temperature regulation are important for pre surgical patient evaluation. *Diagnostic Testing* are often conducted to evaluate organ function and detect subclinical conditions. *Complete Blood Count* (CBC) detects anaemia, infection, and clotting abnormalities. *Serum Biochemistry* assesses liver, kidney, and electrolyte status. *Urinalysis* provides insight into renal and metabolic function. *Radiographs* or *Ultrasound* may be indicated for thoracic or abdominal evaluation in older or at-risk patients. *Electrocardiogram* (ECG) is useful for assessing cardiac rhythm abnormalities, especially in geriatric animals. Blood smear examination is used to rule out haemoprotozoan infection. The *American Society of Anaesthesiologists* (ASA) system is often used to classify anaesthetic risk from Class I (healthy) to Class V (moribund).

Informed Consent and Communication

Clear communication with the animal's owner is essential where risks and benefits of the procedure should be explained, financial estimates and potential complications should be discussed. Informed consent forms must be signed, acknowledging understanding and agreement.

Fasting and Water Withholding

Fasting reduces the risk of regurgitation and aspiration pneumonia during anaesthesia. Generally, Dogs and Cats are fasted for 8–12 hours prior to surgery; water is withheld 2–4 hours before surgery. Puppies, kittens, and toy breeds require shorter fasting times (4–6 hours) to prevent hypoglycaemia. Ruminants require a period of prolonged fasting for 24–48 hours due to large rumen volume and risk of regurgitation. Horses are typically fasted for 6–12 hours; water is usually not restricted. Rabbits, rodents, birds, lab animals etc. are not fasted due to their high metabolic rates and risk of gastrointestinal stasis.

Pre-Surgical Stabilization

Animals presenting with dehydration, anaemia, hypoglycaemia, or systemic illness must be stabilized before proceeding with surgery. IV fluid therapy is required to restore hydration and electrolyte balance. Antibiotics may be administered preoperatively if infection risk is high. Analgesics and sedatives may be used to reduce stress and facilitate handling.

Pre-Anesthetic Medication

Pre-medication facilitates smooth induction and maintenance of anesthesia. *Sedatives* (e.g., acepromazine, dexmedetomidine) reduce anxiety and muscle tone. *Analgesics* (e.g., opioids, NSAIDs) provide pain control before the surgical stimulus. *Anticholinergics* (e.g., atropine, glycopyrrolate) may be used to reduce salivation and manage bradycardia. *Antiemetics* and *gastroprotectants* may be indicated in at-risk animals (e.g., brachycephalic breeds, GI surgeries).

Anesthetic Planning and Equipment Check

Customized anesthetic protocols are developed based on species, size, health status, and procedure type. Anesthetic machine and oxygen source are checked for leaks and function. Monitoring equipment (ECG, capnograph, pulse oximeter, blood pressure cuff) is tested. Endotracheal tubes, IV catheters, and emergency drugs are prepared and sized appropriately. A crash cart should be nearby with emergency medications, defibrillator (if available), and airway management tools.

Surgical Site Preparation

Maintaining asepsis is paramount to reduce the risk of postoperative infections.

Clipping and Cleaning: Hair is clipped around the surgical site using clean clippers. The clipping should be done outside the operating theatre to minimize contamination. The skin is cleaned with warm soapy water to remove dirt, debris, and oil.

Aseptic Scrubbing: Surgical scrub solutions (e.g., chlorhexidine, povidone-iodine) are applied in concentric circles starting from the incision site and moving outward. The area is scrubbed for a minimum of 5 minutes and rinsed with sterile saline or alcohol.

Patient Positioning and Draping

Correct positioning facilitates surgical access and ensures proper ventilation and perfusion. The animal is placed on a surgical table with padding to prevent pressure sores. Positioning aids (troughs, foam pads, sandbags) are used to maintain posture and alignment. Ties and tape may be used to secure limbs gently, ensuring access and safety. Once positioned, sterile surgical drapes are applied by a scrubbed-in assistant or surgeon, to isolate the surgical field during final preparation in the theatre.

Personnel Preparation and Theatre Asepsis

Surgical personnel preparation is vital for aseptic control. Scrubbing of hands and arms using antiseptic soap, sterile gowning and gloving procedures followed strictly, and, surgical masks, caps, and shoe covers worn to prevent contamination are of utmost importance to maintain OT asepsis. The operating theatre should be clean, with minimal traffic, and maintained at a comfortable temperature to reduce hypothermia risk.

Final Pre-Surgical Checklist

A surgical safety checklist should be completed before incision including correct patient identity and procedure confirmed, anesthetic drugs and dosages reviewed, instruments and sterile packs confirmed, emergency plan and drugs reviewed, and monitoring parameters and targets set.

Aseptic Techniques

Infection is one of the most potentially devastating and challenging complications of surgery, which may occur during surgery or at any time during hospitalization. All possible measures should be taken to reduce the risk of *iatrogenic infection*.

Asepsis is defined as the absence of microorganisms that cause disease, which should

be applied to the entire hospital to control the pathogens and to protect both the patient and hospital staff (Aseptic techniques, medical asepsis, clean techniques).

Sterile is defined as being free of all living microorganisms. Sterile technique are more appropriate for the operating room (OR) setting, and applies to work performed in a sterile field. The higher level of protection in a sterile field is critical because the natural defences of the patient are breached by surgical incision, puncture, or introduction of instruments into the vascular system. For example, arthrocentesis performed under sterile technique might require the use of sterile gloves, a sterile patient preparation kit, and a small drape, whereas the same procedure performed using clean or aseptic technique would require only nonsterile gloves and an alcohol wipe.

Transmission of Microorganisms may occur due to contaminated instruments and the environment, but the hospital staff is the most likely means of transmission. The specific means of transmission from staff to patient include airborne, droplet, and contact. Airborne and droplet types of transmission is less common in veterinary hospitals because of the low incidence of reverse zoonosis. Contact from another patient or from an environmental source, is the most common method. During surgery, contact from the patient's normal sources of bacteria such as the skin or nasopharynx may transmit infection to the surgical wound.

Sources of contamination may be divided into animal sources and inanimate sources. Animal sources include the skin and hair, the nasopharynx, and other orifices such as the vulva or anus. Inanimate sources includes fomites and air. One cubic foot of air contains thousands of particles, which can increase to more than 1 million particles during a lengthy surgical procedure, because of traffic into and out of the room and other air currents that develop, and may cause 80% to 90% of microbial contamination of a surgical wound.

Principles of hospital asepsis

Minimization of infection in a surgery practice involves applying principles of aseptic technique throughout the hospital. Goals are to minimize sources of contamination and to block transmission of microorganisms.

- Regular hand washing by hospital staff
- Use of nonsterile or sterile gloves when handling likely sources of pathogens, including high-risk patients (e.g., patients with known infection or wounds),

equipment (e.g., contaminated sponges), and hospital surfaces
- Cleaning or disposal of equipment between patients
- Containment of contaminated supplies and equipment
- Proper storage of equipment
- Regular equipment cleaning protocols
- Proper handling of soiled laundry
- Scheduled cleaning of hospital surfaces
- Proper maintenance of hospital heating, ventilation, and air conditioning systems
- Minimizing unnecessary traffic
- Isolation of patients with known pathogenic microorganisms

Sterile Technique

All surgical procedures are ideally performed under sterile conditions to prevent the transmission of microorganisms into the body during surgery or other invasive procedures.

- Surgical team members should remain within the sterile area, movement in the operating room (OR) by all personnel is kept to a minimum; only necessary personnel should enter the operating room as movement in the OR and outside of the sterile area may encourage turbulent airflow, resulting in cross-contamination.
- Talking is kept to a minimum as it releases moisture droplets laden with bacteria.
- Nonscrubbed personnel should not reach over sterile fields as dust, lint, or other vehicles of bacterial contamination may fall on the sterile field.
- Scrubbed team members should face each other and the sterile field at all times as the back is not considered sterile even if wearing a wraparound gown.
- Equipment used during surgery must be sterilized, and scrubbed personnel should handle only sterile items; nonscrubbed personnel handle only nonsterile items as non-scrubbed personnel and unsterile instruments may be a source of cross-contamination. If the sterility of an item is questioned, it is considered contaminated.
- Sterile tables are sterile only at table height. Items hanging over the table edge are considered nonsterile because they are out of the surgeon's vision. If the surgical team begins the surgery seated, they should remain seated until the surgery has been completed. The surgical field is sterile only from table height to the chest; movement from sitting to standing during surgery may promote cross-contamination.
- Sterile drapes are used to create a sterile field Drapes covering instrument tables or the patient should be moisture proof as moisture carries bacteria from a nonsterile surface to a sterile surface (strike-through contamination). Sterile items within a damaged or wet wrapper are considered contaminated.

- If a sterile object touches the sealing edge of the pouch that holds it during opening, it is considered contaminated. Once opened, sealed edges of pouches are not sterile.
- Hands may not be folded into the axillary region; rather, they are clasped in front of the body above the waist. The axillary region of the gown is not considered sterile. Gowns are sterile from mid-chest to waist and from gloved hand to 2 inches above the elbow.
- All items introduced onto a sterile field should be opened, dispensed, and transferred by methods that maintain sterility and integrity; the sterile field should be maintained and monitored constantly.
- Surgical staff should be trained to recognize when they have broken technique and should know how to remedy the situation.

An Information on Gynaecological Operative Procedures in Dogs and Bitches

Ankesh Kumar[1] and CS Azad[2]
Veterinary Clinical Complex[1]
Departmet of Veterinary Gynaecology & Obstetrics[2]
Bihar Veterianry College, Patna- 800014.

Transmissible Venereal Tumour in Dogs

Canine transmissible venereal tumour is a naturally occurring tumour transmitted from animal to animal during copulation by viable tumour cells and is also called as transmissible venereal tumour, canine transmissible venereal sarcoma, sticky tumour that mainly affects external genitalia and occasionally the internal genitalia. TVT has been recorded all over the world and is most common in subtropical to tropical areas. A large stray dog population and uncontrolled sexual behaviour appear to be one reasons for high incidence of TVT. In India incidence of TVT in dogs isreported to range from 23-43%. TVT is seldom or no more detected in north America, Mainly due to the population control of stray animals, the preventive pre-breeding examination and the effective treatment of clinical cases.The tumour is seen most commonly in sexually active male and female dogs (2-8 years of age) allowed to roam freely. Female are infected more often than male.

Etiopathology

The origin of this tumour has been extensively studied. The most common mode of transmission is during mating, where tumor cells are transferred from the affected genitalia of one dog to the mucosa of another. Although a viral cause has been postulated but not verified, recent research confirms that the tumour is clonal in origin, and the development of this tumour requires transmitting the neoplastic cells from one dog to another. Presently, the consensus view is that TVT arise from allogenic cellular transplant and that the abnormal cells of the neoplasm are the vectors of transmission. The exfoliation and transplantation of neoplastic cells during physical contact provide the main mode of transmission onto genital mucosa and also onto nasal or oral mucosa during mating or licking of affected genitalia, respectively. The implantation of the tumour is facilitated by the presence of any mucosal lesion or by the loss of mucosal integrity

Clinical Signs and symptoms

The common clinical signs observed include a serosanguineous or pure haemorrhagic vaginal or preputial discharge, protrusion of the neoplastic lesions and

deformation of the external genitalia. TVT s are single to multiple, pink-red, nodular, papillarymultilobulated, cauliflower-shaped or pedunculated lesions that very greatly in size and can exceed up to 15 cm diameter when progress deeper inti the mucosa. Neoplasm are relatively firm but fragile. The superficial part is commonly ulcerated and inflamed and breeds.

In female dogs the neoplastic lesions are usually located at vestibule, often at the junction of the vestibule and the vagina perhaps due to high pressure exerted on this area during matting. It protrudes from the vulva.

In the male dogs the tumour is usually located on the caudal part (Bulbus landis) and Less often on the shaft (Pars longa glandis) or the tip of the glans penis and occasionally on the prepuce. The serosnaguinous or haemorrhagic discharge may be confused with oestrus, Urethritis or cystitis in the male with prostatitis. The tumour can cause mechanical obstruction to the flow of urine, dystocia in whelping female and phimosis and paraphimosis in the male. The general health of the affected dogs is not impaired unless the tumour become necrotic and infected or occlude the urethral orifice or metastasised.

Microscopic characteristic

Aspirates from TVTs are highly cellular and often bloody. Cytological examination revels the typical round to slightly polyhedral cells. The most prominent cytological feature of TVTs is presence of distinct,clear, cytoplasmic vacuoles.

Diagnosis

Definitive diagnosis is based on physical examination and cytological finding typical of TVT in exfoliate cells obtained by swab, fine needle aspiration or imprints of the tumours.

Treatment

Surgery, radiotherapy, immunotherapy, and chemotherapy have been applied for treatment of TVT.

Surgery has been used extensively for the treatment of small, localized TVT, although the recurrence rate was high as 50-68% in cases of large invasive tumours. The tumours cells transplanted into the surgical wound during operation is source reoccurrence. The use of electrocautery makes the operation easier and a little more effective. However, it is still far from being suggested as the first choice.

Chemotherapy has been shown to be the most effective and practical therapy. Antimitotic agents, such as cyclophosphamide, methotrexate, vincristine are the chemotherapeutic drugs for treating TVT, Vincristine sulphate being the most

frequently used drug.

Vincristine is administered weekly at a dose of 0.025 mg/Kg, I/V. The involution of the lesions is gradual, although noticeable and significant at the beginning of the treatment. The complete remission usually takes 2 to 8 injections and occurs in more than 90% of the treated cases.

Temporary side effects are partial anorexia, mild depression, fever and volition are reported in less than 20% of the treated dogs.

Prognosis

The prognosis for TVTs is very good. Less than 5% of TVTs metastasize to other sites. Vincristine sulphate is the treatment of choice with majority of dogs being cured. Even in the case of the metastasis the cure rate for TVTs is over 90%.

Control

Control of TVT is difficult because stray dogs serve as a reservoir. Dog owners and breeder should carefully examine all male and female before mating and should also prevent mingling of valued dogs with stray.

Pyometra in Dogs

Pyometra is a serious and potentially life-threatening infection of the uterus that causes it to fill with bacteria and pus. Many dogs with a pyometra have vaginal discharge and may feel very sick with a poor appetite, lethargy, vomiting and sometimes increased thirst or urination. This infectious and inflammatory disorder of the uterus typically occurring in adult, intact bitches during or immediately after the luteal phase of the estrous cycle. The clinical signs of pyometra are often nonspecific and vary among patients depending on the chronicity of the disease and the patency of the cervical canal. Early recognition, diagnosis, and treatment of pyometra are necessary to achieve a successful outcome. The condition must be treated quickly and aggressively.

How Does Pyometra in Dogs Happen

Unneutered female dogs that still have reproductive organs are more likely to get pyometra, especially when they are over age 6.

The chances of developing pyometra are higher when your unneutered dog is out of heat. During this time, the dog goes through hormonal changes. When the heat period is over, most dogs return to normal. But, some may develop an infection or pyometra in their uterus.

As the infection grows, the uterus gets filled with pus. If not treated on time, the pus can cause blood poisoning, peritonitis, kidney failure, or even death.

Pyometra can be 'open' or 'closed.' In an open pyometra, the uterus' entry remains open, and you can see pus or blood coming out of your dog's vulva.
In closed pyometra, the uterus is shut, and you can't see the discharge. This condition is more dangerous as the uterus can burst
In rare cases, a dog who has already been neutered may also develop a particular type of pyometra called a stump pyometra. It happens when a small uterus stump remains inside the dog and gets infected.

What Causes Pyometra in Dogs?
The primary cause of pyometra in dogs is hormonal change during each heat cycle. The cycle changes the uterus and makes it thicker with tissues to support pregnancy. When these changes keep happening, the uterus can change permanently and have excess tissue.

The transformation of the uterus makes it more vulnerable to infection. It also weakens the uterus' ability to fight off any infectious bacteria.
Pyometra commonly happens due to the E. coli bacterium, mostly a few weeks after the female dog completes the heat period.

Progesterone-based drugs can also cause pyometra due to the changes they make in the uterus. Dogs already taking hormone therapy for treating conditions of the reproductive system must be monitored for pyometra.

What Are the Signs of Pyometra in Dogs?
The symptoms of pyometra in dogs usually start after four to eight weeks of a heat period. The common ones include:
- An increased urge for water
- Nausea or vomiting
- A discharge from the vulva (pus)
- Bloated tummy
- Frequent panting
- Fatigue
- Appetite changes
- Increased urination

Diagnosis
Your veterinarian will diagnose a pyometra based on physical exam findings, such as vaginal discharge and a history of a recent heat cycle. Your veterinarian may also use any of the following tests to confirm a diagnosis:
- Ultrasound or X-rays to identify an enlarged, fluid-filled uterus
- Blood work

- Urine sample
- Vaginal cytology

Treatment

A pyometra is a medical emergency that requires prompt treatment. The mainstay of treatment includes:

- IV fluids
- Antibiotics
- Ovariohysterectomy

Pyometra is best treated with surgery to remove the ovaries and uterus (spay). The surgery for a pyometra is often more complicated than a spay for a normal, healthy dog. Some dogs may require more intensive care and monitoring for signs of sepsis, dehydration, shock, anemia and more.

Medical management involves injections of the hormone prostaglandin, fluids and antibiotics. However, it is rarely considered and generally discouraged except for specific cases, such as a young, valuable breeding dog. It is not a viable option for a critically ill dog or one with a closed pyometra. Medical management takes several days before showing improvement, and some may not improve at all and may ultimately require surgery. Additionally, medical management has many side effects, including panting, drooling, diarrhea, vomiting and even the potential rupture of the uterus, which could be life-threatening.

Outcome

Untreated pyometra can be deadly from overwhelming infection and sepsis. However, most patients have a good prognosis when diagnosed and treated with surgery early. Dogs that develop sepsis or have a ruptured uterus often have a worse prognosis. Dogs that are treated medically often experience a recurrence of infection.

Prevention

Pyometra is entirely preventable if a dog is spayed before the development of infection in the uterus. A spay to remove the ovaries and uterus is recommended to prevent pyometra. If a dog is intended for breeding, they should be bred at the appropriate age to minimize their risk of developing a pyometra. Having your dog spayed while young and healthy is safer and less costly than waiting for an emergency pyometra spay.

Ovariohysterectomy (OH)

One of the most common surgical procedures performed on dogs is spay, also known

medically as am ovariohysterectomy (removal of Ovary and the uterus)
The most frequent indication for OH is the elective sterilization. It is the treatment of choice for most uterine disease including pyometra, localized or diffused cystic endometrial hyperplasia, uterine rupture and neoplasia. In addition, it may be justifiable adjuvant therapy for mammary neoplasia and hence preventing the female dogs from getting mammary tumour later in life

Contra-Indications: No important contraindications for this techniques have been described. However, some limitations include the need for multiple assistant for deranged biochemistry.

Procedures
The dog will need to be fasting (no food or water) the night before surgery and the day of surgery. Prior to anaesthesia, the dog blood will be tested to ensure her organs are functioning properly.

- The procedure takes about 45 minutes to an hour to perform in most cases, including the needed time for preparation and anaesthesia. In older or large-breed dogs the procedure can take longer and may require two surgeons.
- A pre-aesthetic, pain medication, and antibiotic are administered by injection to the dog.
- The dog will be feeling drowsy from the pre-anaesthetic/sedative, but mask gas anaesthesia will likely follow to allow the dog to rest comfortably.
- The anesthetized patient is placed on the surgical table in dorsal recumbence (on the back). The hind legs are tied cranially for stabilization purpose
- The patient will have the hair clipped close to the skin in a section from the xyphoid to the pubis. The freshly clipped area will then be scrubbed for surgery.
- A sterile drape is placed over the surgical site of dog, creating a sterile field. The drape is clamped in place and an opening is made in the drape, just above the focus point of the surgery.
- An incision is made using a scalpel blade, typically created over the midline just caudal to the umbilicus. The incision will pass through the subcutaneous tissues, fat and eventually, the peritoneal cavity.
- The organs of the female reproductive tract are identified and the major blood vessels supplying the ovaries and the uterus are ligated (tied off). This must be done before these organs can be removed. Sutures (stitches) that dissolve over time are used to tie off the blood vessels and also to close the uterus above the cervix. Sometime, surgical staples are used in place of sutures.
- The uterus is located using a hook. The uterine horn will be gently pulled through

the incision opening and Kelly forceps will be used to grasp the reproductive organ.

- The uterus is dissected and tied off with 0 or 2-0 monofilament absorbent sutures. Several sutures will be placed to ensure closure.
- The excess tissues from the pedicle are removed and inspected for bleeding. If no bleeding is present, the uterine pedicle is placed back into the peritoneal cavity.
- The surgical opening, including all layers of the abdominal wall, will be sutured with monofilament absorbent sutures. The outer layer of skin is closed with skin glue, sutures, or surgical staples; these sutures and staples need to be removed in about 10 to 14 days.
- Dogs need to be kept quiet in the post-operative period to encourage healing and help prevent complications. Most dogs can resume normal activity 5-10 days after surgery. Until then, leash walks, lots of rest, and no swimming, bathing, or running is advised. Elizabethan collars (E-collars) or alternatives to the E-collar used to prevent your dog from being able to lick at her incision are often recommended.

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Basic Principles of Radiography

Ramesh Tiwary
Dept. of Veterinary Surgery and Radiology,
Bihar Veterinary College, Patna-14

Radiography is a commonly used diagnostic tool in veterinary practice. X-ray images (radiographs) allow radiologists and other specialists to examine the body for injury or disease. Not only used for bones, radiographs also provide examination of the heart, lungs, and abdominal organs. Radiography is often the first line of diagnostic imaging with which a radiologist can either make a diagnosis, or direct the need for further imaging. It is quick, painless, and economical tools of diagnostic imaging.

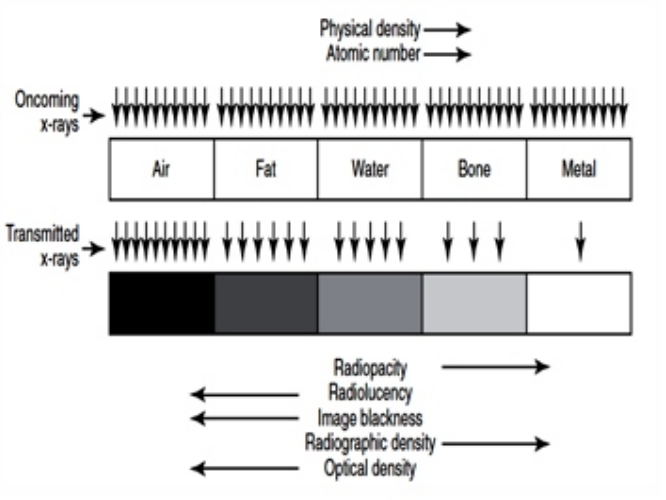
X-ray machines
Variety of X-ray machines are now a days available in veterinary field. They can be of following types.

Mobile/Portable X-ray machines
These are low voltage x-ray machines (70-150 mA) and are used for making radiographs of extremities of animals i.e. bones below carpus or tarsus joints. Commonly used in veterinary field and are portable ones.

Ceiling suspension X-ray machines
These are high voltage X-ray machines (300-1000 mA) and are generally used for large animal radiography. With these machines radiography of abdomen and chest is possible but these needs setting up of very high exposure factors.

Moving Grid X-ray machines
They are generally used for radiography of dogs, cats and small ruminants.

Radiographic Density
Radiographic density is the measure of the degree of blackness on a processed film and is directly related to the number of X rays reaching the film. More the number of X-rays that reach the film, blacker it is i.e. higher is the radiographic density. Radiographic density is inversely proportional to the subject density as denser the object more it absorb s X-rays so that less photons reach the film. Main densities which can be appreciated on a radiograph are i) metal, mineral and bone, ii) fluid (soft tissue), iii) fat, and iv) gas



Interpreting Abdominal Radiographs

Some important radiographic features of disorders involving various structures are described below.

Diaphragm

The diaphragm should be evaluated for its integrity. In case of diaphragmatic hernia, the abdominal viscera can be visualized in the thoracic cavity across the diaphragm.

Liver and Gall Bladder

Diffuse

Hepatomegaly in dogs may be evaluated by assessing the axis of the stomach. In most dogs, the long axis of stomach is parallel to the rib cage on lateral view. Generalized enlargement of the liver produces characteristic displacement of the pylorus and pyloric antrum caudally, dorsally, and to the left. In many instances the enlarged caudoventral edge of the abnormal liver can be seen as it projects beyond the costal margin.

Spleen

On a lateral radiograph the tail of spleen in dogs is seen in the ventral abdomen dorsal to the falciform fat and caudal to the stomach at about the level of the umbilicus. It is less commonly seen on lateral radiographs of cats. Spleen should be considered enlarged if its edges are round and displaces adjacent viscera.

Stomach

Normal canine stomach lies transversely across the abdomen with the fundus located on the left side of the midline on VD radiograph and in a cranio-dorsal position on lateral radiograph. Pyloric antrum is located to the right of midline on VD view and ventrally on the lateral view.Acute Gastric Dilation and Volvulus (GDV) can be easily diagnosed on a lateral projection with classical radiographic feature of compartmentalization of stomach or "double bubble appearance" which can be appreciated on lateral and VD views.

Small Intestine

Normalserosal margins should be smooth and are most easily seen adjacent to the abdominal wall, where there is less superimposition of other structures. Young and emaciated animals have poor serosal definition owing to lack of intra-abdominalfat.Normal small bowel diameter should not exceed the height of the central part of the body of a lumbar vertebra or the diameter of the SI in dogs should not be more than 1.6 times the height of the center of the 5th lumbar vertebra.

Cecum

Cecum is located to the right of midline at the level of L2 and L3 on the VD radiographs, with a characteristic gas distended 'C' shape, spiral or comma shape.

Colon

The ascending, transverse and descending colon can be easily identified on the VD projections. Megacolon is diagnosed of the diameter of colon exceeds the length of L7 vertebra.

Urinary Bladder

The commonest abnormality identified in the bladder on plain radiographs are radiopaque calculi. The prostate lies immediately caudal to the neck of the bladder. In young dogs the prostate is located within the pelvic canal. As the dog ages the prostate will tend to be located further cranially. The same cranial displacement also occurs with enlargement of the prostate. The most reliable assessment of the dimensions of the prostate are the transverse diameter should be no greater than 75% of the distance from the ventral surface of the sacrum to the floor of the pelvis.

Kidney

In the dog the normal size of kidney is 2.5-3.5 times the length of the second lumbar vertebra. In cats it is 2-3 times the size of L2. Focal increases in sizes or changes of shape of the kidney are typically associated with either abscess or a neoplastic process.

Reproductive Tract

Enlargement of the uterus is associated with either pregnancy or pyometra. The radiographic differentiation of early pregnancy and pyometra can be difficult. The presence of mineralized fetal parts is the most helpful radiographic sign in determining pregnancy. Mineralization of the fetal skeleton begins at approximately forty to forty five days and is not complete until immediately prior to the term. Fetal death leads to putrefaction and presence of gas in fetus and uterus (visible after 24 hours of death). In pyometra the enlargement of the uterus can become very extensive.

Interpretation of thoracic radiographs

At least three well-positioned orthogonal radiographic views i.e left lateral, right lateral and a DV or VD view are essential for complete evaluation of the thoracic structures. Most radiologists describe radiographic changes within the lung tissue on the basis of lung patterns. There are 4 major categories of lung pattern - these correspond to the component of the pulmonary tissue that is altered. The 4 major categories are:

Interstitial Lung Patterns

The interstitial lung pattern may be nodular or military. In Miliary interstitial pattern there are fine dotted (bread mould) pattern in the lungs (e.g. Blastomycosis). The nodular lung pattern may be structured or unstructured. Structured nodular pattern shows increased nodular densities having distinct, well-defined margins (e.g., neoplasia, chronic granulomas).

Alveolar Lung Pattern

The alveolar pattern may be localized or diffused. May involve a single lung lobe (Lobar sign) or multiple lung lobes. Characteristic findings may include air bronchograms, loss of cardiac silhouette and silhouetting of the pulmonary vasculature and Patchy, poorly defined, increased densities with fluffy, indistinct margins which tend to coalesce.

Bronchial Lung Pattern

The bronchial lung pattern is defined by increased visualization of the bronchi walls. Increased bronchial visualization may be present because of bronchial wall calcification, bronchial wall thickening or the accumulation of peribronchial infiltrates. The bronchial walls seen side-on are linear and parallel. For this reason, the side-on bronchi are commonly referred to as "tram-lines" or "train-tracks". The end-on bronchi appear as circular structures with a radiolucent centre and referred to as "doughnuts".

Vascular Lung Pattern

A vascular pattern is present when the amount of blood in the larger arterial or venous branches is increased or decreased. This causes the vessels to change in size, shape and direction. On a VD/DV view the caudal pulmonary vessels are compared to the 9th rib at the point where they cross this rib. In normal animals the vessels should never be of greater width than the rib. On a Lateral view the cranial pulmonary artery and veins are compared with each other and should be of equal width. Any alteration is indicative of disease process. The width of the vessels on this view should not be greater than the width of proximal third of the 4th rib.

Radiographic assessment of the heart

On lateral radiograph (Right lateral or Left lateral) of the canine thorax, the heart is oriented at approximately 45 degree angle, is situated between the 3rd-8th thoracic vertebrae, and occupies about 3 intercostal spaces. In general a rule of thumb states that a normal cardiac silhouette in the dog usually ranges from 2.5 to 3.5 times the width of intercostal spaces. However this also may not be true in the cases. The vertebral heart scale (VHS) is a method for cardiac measurement that compares the dimensions of the cardiac silhouette with the length of thoracic vertebral bodies. The generic normal range is 8.7-10.7. VHS measurements tend to increase in dogs with cardiac disease. In cats the VHS critical limit is set at 8.5.

Ultrasonography in Small Animals

Pallav Shekhar
Dept. of Veterinary Clinical Complex
Bihar Veterinary College, Patna-14.

Ultrasonography is a non-invasive diagnostic imaging technique that uses high-frequency sound waves to visualize internal body structures in real-time. In small animal practice, especially for dogs and cats, ultrasonography has become an indispensable tool for clinicians due to its safety, repeatability, and ability to provide detailed anatomical and functional information.The application of ultrasonography in companion animals began gaining popularity in the late 20th century, paralleling advancements in veterinary diagnostic imaging. It is now routinely used for evaluating abdominal organs, thoracic structures (in the absence of air interference), musculoskeletal conditions, and even guiding minimally invasive procedures such as biopsies and fluid aspirations.Ultrasound is particularly valuable in detecting conditions such as pyometra, renal diseases, hepatic abnormalities, splenic tumors, urinary tract obstructions, gastrointestinal disturbances, and pregnancy diagnosis. Echocardiography, a specialized form of ultrasonography, plays a critical role in diagnosing and monitoring cardiac diseases in dogs and cats.

Unlike radiography, ultrasonography does not involve ionizing radiation, making it safer for repeated use, including in pregnant animals. The development of portable and high-resolution ultrasound machines has further expanded its accessibility in first-opinion practices and emergency settings.As technology continues to evolve, ultrasonography is increasingly being integrated with other modalities such as Doppler imaging and contrast-enhanced studies, enhancing its diagnostic capabilities in veterinary medicine.

Principles of Ultrasonography

Ultrasonography is based on the principle of sound wave reflection. It uses high-frequency sound waves (ultrasound), typically between 2 to 15 MHz, which are emitted by a transducer (probe). These sound waves penetrate the body and interact with different tissues. Depending on the density and composition of the tissue, the sound waves are:

a) Reflected back to the transducer
b) Transmitteddeeper
c) Scattered/absorbed

The transducer receives the returning echoes, and the ultrasound machine processes these signals to create a real-time image of internal structures.

Key principles include

1. Acoustic Impedance

Each tissue has a unique acoustic impedance (resistance to sound wave transmission). The greater the difference in impedance between two tissues, the stronger the reflected echo.

2. Echo Generation

Tissues that reflect many sound waves appear hyperechoic (bright), while those that reflect few appear hypoechoic (dark). Fluid-filled structures (e.g., bladder, cysts) are typically anechoic (black) because sound waves pass through them without reflection.

3. Attenuation

As sound waves travel through tissue, their intensity diminishes due to absorption and scattering. This is called attenuation, and it increases with depth and frequency.

4. Resolution vs. Penetration

High-frequency probes (7–15 MHz) provide better resolution but less penetration—ideal for superficial structures.

Low-frequency probes (2–5 MHz) offer deeper penetration with lower resolution—used for large dogs or deep abdominal organs.

5. Doppler Effect

Doppler ultrasonography utilizes the frequency shift of echoes from moving blood cells to assess blood flow direction and velocity, crucial in cardiovascular evaluation.

6. Real-Time Imaging

The ultrasound machine updates images continuously, allowing dynamic assessment of organ movement, peristalsis, heart function, and fetal viability.

Modes in Ultrasonography

Ultrasonography operates in several modes, each suited for specific diagnostic purposes.

1. A-Mode (Amplitude Mode)

Description: Oldest and simplest form; displays echoes as vertical spikes on a graph.

Application: Rarely used in clinical practice today. Previously used for measuring fat

or eye axial length.

2. B-Mode (Brightness Mode)
Description: Most commonly used mode in veterinary practice. It creates a two-dimensional grayscale image, where each echo is represented by a dot with brightness corresponding to echo intensity.
Application: Abdominal organ evaluation, pregnancy diagnosis, thoracic structures, musculoskeletal assessments, etc.

3. M-Mode (Motion Mode)
Description: Captures motion of a single scan line over time, producing a wave-like graph.
Application: Primarily used in cardiology to assess heart wall and valve motion (e.g., in dogs with mitral valve disease or dilated cardiomyopathy).

4. Doppler Mode
Used to assess blood flow in vessels and heart. It includes several subtypes:
a) Color Doppler
I. Displays blood flow direction and velocity using color (red and blue).
II. Application: Evaluating blood flow in organs or heart.
b) Power Doppler
a) More sensitive than color Doppler; detects low-velocity flows but doesn't show direction.
b) Application: Detecting small or slow-flowing vessels (e.g., in tumors).
c) Pulsed-Wave Doppler
a) Measures flow velocity at a specific location.
b) Application: Quantifying blood flow through heart valves or vessels.
d) Continuous-Wave Doppler
a) Measures high-velocity flow continuously along a line.
b) Application: Useful in assessing severe valvular stenosis or regurgitation.

5. 3D and 4D Modes(Advanced)
a) 3D Mode: Provides volumetric imaging of structures.
b) 4D Mode: Real-time 3D imaging (moving 3D).
c) Application: Rare in routine veterinary practice; may be used in specialized reproductive or cardiac imaging.

Ultrasound Transducers and Their Applications:
Transducers, or probes, are essential components of an ultrasound machine. They

generate and receive high-frequency sound waves. Different types of transducers are used based on frequency, shape, and field of view, depending on the clinical application and body part being examined.

Types of Transducers Used in USG

1. Linear Transducer

Frequency: High (7.5–15 MHz)
Shape: Flat, rectangular surface
Image: Rectangular field of view
Application
Superficial structures (e.g., tendons, lymph nodes)
Small animal abdomen (superficial organs in cats/small dogs)
Mammary gland, thyroid, skin masses
Vascular access and nerve blocks

2. Curvilinear (Convex) Transducer

Frequency: Medium (3.5–8 MHz)
Shape: Curved surface
Image: Sector-shaped field of view (wider than linear)
Application
General abdominal examination in dogs and cats
Pregnancy diagnosis
Liver, kidney, spleen, urinary bladder
Deeper structures in medium to large dogs

3. Microconvex Transducer

Frequency: Medium to high (5–10 MHz)
Shape: Small curved footprint
Image: Small sector image
Application
Ideal for cats and small breed dogs
Intercostal scanning (e.g., echocardiography)
Neonates and pediatric animals
Ocular and cranial imaging

4. Phased Array Transducer

Frequency: Low to medium (2–5 MHz)
Shape: Small square or circular face
Image: Sector (pie-shaped) field of view

Application:
Echocardiography in all breeds
Useful in tight spaces (e.g., between ribs)
Thoracic imaging

5. Endocavitary / Endorectal Transducer
Frequency: High (7–10 MHz)
Shape: Long, narrow probe
Image: Curved or linear
Application
Rectal or vaginal scanning in small animals
Prostate gland evaluation
Reproductive tract in bitches and queens

Patient Preparation and Positioning of Dogs for Ultrasonography
Proper patient preparation and correct positioning are essential for obtaining high-quality and diagnostic ultrasound images. This ensures minimal artifacts, better organ visualization, and accurate interpretation.

I. Patient Preparation
1. Fasting
Duration
8–12 hours prior to abdominal ultrasound
Purpose
Reduces gas in the stomach and intestines, which can interfere with sound wave transmission and image quality.
Note: Fasting is not necessary for emergency cases.

2. Bladder Filling
A moderately full urinary bladder provides better evaluation of the bladder wall and adjacent organs.
Encourage the dog not to urinate for at least 2–3 hours before the exam if urinary tract evaluation is intended.

3. Hair Clipping
The area to be scanned should be liberally clipped to ensure proper contact of the transducer with the skin.

Common clipping sites:

Abdomen: From xiphoid to pubis and laterally to the flanks
Thorax (for cardiac scans): Over the left/right thoracic wall (4th to 6th intercostal space)

4. Coupling Gel
Ultrasound gel can be applied to eliminate air between the transducer and the skin surface for optimal sound wave transmission.

5. Sedation
Usually not required, but mild sedation (e.g., with butorphanol or acepromazine) may be used in anxious, aggressive, or non-cooperative dogs, especially for prolonged or painful evaluations.

II. Patient Positioning
The positioning depends on the organ system being evaluated
1. Abdominal Ultrasonography
The most Common Position is dorsal recumbency (dog lies on back) using a V-trough or foam support. This allows access to entire abdomen, including liver, spleen, kidneys, intestines, and bladder.Alernatively, lateral recumbency(left or right side) can be used in fractious or uncomfortable animals.

2. Echocardiography (Cardiac Ultrasound)
For echocardiography right or left lateral recumbency can be done. Left lateral is commonly used for right parasternal view (standard in veterinary cardiology).A soft table or cut-out "echocardiography table" can be used for probe access from beneath.

3. Thoracic Ultrasonography
For this lateral or sternal recumbency depending on the region of interest can be done.
Application
For pleural effusion, lung consolidation, or mediastinal masses.

Methods of using probe in ultrasonography
In small animal ultrasonography, several probe manipulation techniques are used to obtain optimal images and thoroughly evaluate internal structures.
I. Fanning: It involves pivoting the probe on its fixed point in a sweeping motion to scan through an organ in multiple slices without changing the probe's location.
II. Sliding: It is the movement of the probe linearly across the skin surface to shift from one region to another.

III. Rotating: It means turning the probe clockwise or counterclockwise to change the scanning plane, such as from longitudinal to transverse.

IV. Tilting (or heel-toe maneuver)

It adjusts the angle of the probe by lifting or lowering one end, which helps in visualizing structures at different depths or angles.

V. Rolling

It refers to a gentle rotation along the long axis of the probe to refine image alignment. These techniques are essential for comprehensive and dynamic assessment of organs in dogs and cats, ensuring accurate diagnosis.

Artifacts and their Applications in Ultrasonography (USG)

Artifacts in ultrasonography are image distortions or errors that occur due to the interaction of ultrasound waves with tissues and interfaces in ways not anticipated by standard assumptions. While some artifacts may obscure diagnostic detail, others can be useful in identifying specific conditions or structures. Understanding them is crucial for accurate interpretation.

Common Ultrasound Artifacts and Their Applications

1. Acoustic Shadowing

Description

It appears as a dark band (shadow) distal to a highly reflective or absorptive structure.

Cause

Sound waves are blocked or absorbed (e.g., by bone, calculi).

Application

It is useful in detecting urinary calculi, bone, or gas. Presence of shadow confirms the density of the object.

2. Acoustic Enhancement (Posterior Enhancement)

Description

Increased echogenicity (brightness) behind fluid-filled structures.

Cause

Sound waves pass easily through fluid, leading to stronger echoes from deeper tissues.

Application

It helps to identify cysts, urinary bladder, gallbladder, and uterine fluid in pregnancy.

3. Reverberation Artifact

Description

Multiple equally spaced bright lines appearing due to repeated reflections between strong interfaces.

Cause

Occurs between the probe and a highly reflective surface (e.g., gas or metal).

Application: It Indicates the presence of gas(as in intestines or pneumothorax) or foreign metallic objects.

4. Mirror Image Artifact

Description

A duplicate image of an organ appears on the other side of a strong reflector.

Cause

Sound waves reflect off a curved surface like the diaphragm before returning.

Application

It is seen in hepatic imaging, may help identify diaphragmatic hernias.

5. Edge Shadowing

Description

Dark lines appearing at the edges of round or curved structures.

Cause

Refraction and scattering at curved surfaces.

Application

It is commonly observed in kidneys, gallbladder, urinary bladder, and can help confirm shape and border.

6. Comet Tail and Ring-Down Artifact

Description

Bright tapering lines extending from a source.

Cause

Reverberation in very small, closely spaced structures or air bubbles.

Application

It is seen in gas pockets, helps in diagnosing emphysematous conditions, intestinal gas, or abscesses with gas.

Diagnostic Approaches to Veterinary Parasitic Infections

Ajit Kumar and Pankaj Kumar
Dept. of Veterinary Parasitology,
Bihar Veterinary College, Patna-14

Parasitic infections cause severe morbidity and mortality in animals and thus affect the economy of livestock owners by decreasing the ability of the farmer to produce economically useful animal products. Parasitic infections adversely affect animal's health and threaten profitable animal production, thus affecting the economy of our country.

Parasites infection/infestation	**Economic losses due to parasitic infection or gain after parasitic treatment**	**References**
Helminthic infection	Increased 12 litre milk in 100 days after anthelmintic treatment	Sanyal *et al.* (1992)
Paramphistomosis	1.60 litre/day in cow and 1.31 litre in buffaloes after anthelmintic treatment	Kumar *et al.* (2007)
Helminthic infection	Increased milk production 04 -18 percent in cow after anthelmintic treatment	Das *et al.(*2017)
Tick and Tick - bornediseases (TTBDs)	13.9- 18.7 billion US $ losses in production annually in the world	De Castro (1997)
Tropical bovine theileriosis	800 million US $ losses in India	Devendra (1995)

Economic losses of farmers (due to decreased milk production, draught power capability and reproduction performance) can be minimized by controlling parasitic infections in animals.Appropriate control measures against parasitic infections is mainly dependedupon the detection of parasites.Diagnosis of parasites generally done on the basis of symptoms or detection of parasites or its stages from the materials collected from the herds and the flock by necropsy.

Samples to be required for the diagnosis of various parasites:

- Faeces
- Blood
- Nasal scraping

- Urine
- Lymph node biopsy
- Skin scraping
- Sputum

A. Faecal Examination:
Gastrointestinal parasites:

Helminths			Protozoa
Nematodes (round worms)	**Cestodes (Tapeworms)**	**Trematodes (Flukes)**	
Ancylostoma spp. (Hook worm), *Haemonchus contortus* (Barber pole worm) , *Toxocara vitulorum*(Ascaris of calf), *Strongylus* etc.	*Moniezia expansa, Moniezia benedeni, Taenia solium, Dipylidium caninum, Echinococcus granulosum* etc.	*Fasciola* spp. (liver fluke), Amphistomes, Schistosomes (blood flukes) etc.	*Entamoeba histolytica*, *Giardia* spp., *Balantidium coli*, *Eimeria* spp. (Coccidia), *Cryptosporidium* spp., *Toxoplasma gondii*etc.

Faecal Examination Methods:
To diagnose or detect the gastro intestinal parasites or it's eggs and other stages.

Materials/Equipment to be required for the diagnosis of Gastro-intestinal Parasites:-
- Specimen collecting vial
- Faeces
- Glass slide
- Tooth pick
- Cover slip
- Microscope
- Formalin (10 %)
- Ethyl alcohol
- Lugol's Iodine
- Camel hair brush

Collection of faeces

Faecal samples should be collected from the rectum of the suspected animals because such samples give a more reliable picture of the infection. In large animals collection of faeces from the rectum can be done by hand without difficulty. Smaller animals such as lamb and dogs can be induced to defecate by inserting a moistened little finger into the rectum and gently massaging with a rotatory motion and then sample may be collected. For collection of samples use stoppered wide mouth bottles 20-30 ml capacity (for dispatching) or petridishes (for early examination). A sufficient amount of faces should be collected, specially of the herbivores, as their faces contain considerable amount of roughage. Care should be taken during the collection of faecal samples that they should not be intermixed with the animal's faeces.

Preservation of collected faecal samples

Since eggs embryonate rapidly, the faeces should be stored in the refrigerator unless examination is carried out within a day. Some timesfaecal samples sent to laboratory examination for long Distances through the post, the addition of twice the volume of 10 % formal into the faeces will minimize development and hatching.

Examination of Faces

(A) Gross examination of Faces

Faces are examined in the first place for adult parasites, larval stages of insects(e.g. bots) and segments of tape worms.

(B) Microscopic examination

(a) <u>Direct smear method</u>

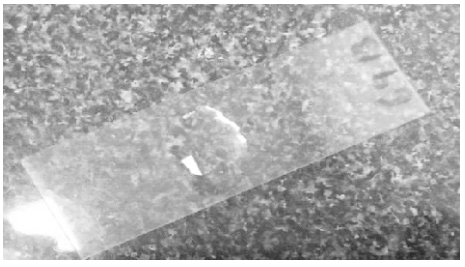
A small quantity of fresh faces is placed on a slide, mixed with a small droplets of water or normal saline with the help of needle evenly spread over the slide and coverslip is placed on the fluid and examined under low power microscope.

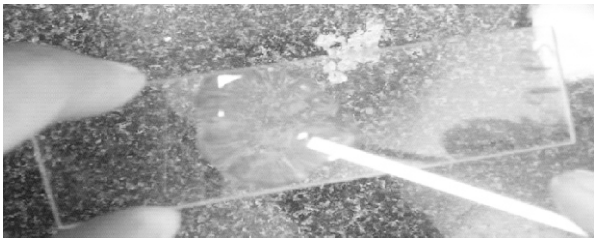
Advantages

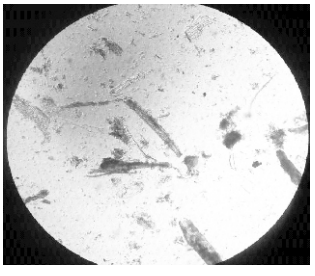
1. This is a simple technique and can be performed at field condition without any equipment.
2. This is a quick test, so that large number of samples can be performed in a very short time.
3. This test is useful in the diagnosis of (i) heavy coccidian and helminthic infections and (ii) cestode and trematode eggs (mainly in birds).

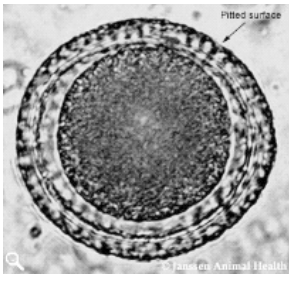
Disadvantage

1. This method is qualitative so severity of the infection can not be determined.
2. It is usually fails to detect low grade infection and is only suitable when the Concentration of parasitic stage is high.

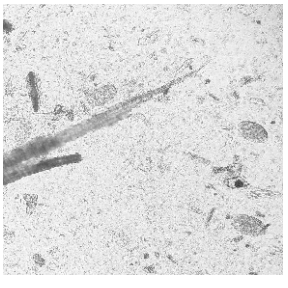




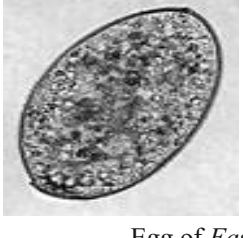


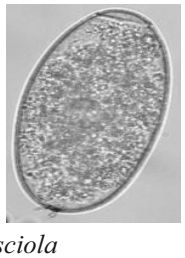


Egg of *Toxocara vitulorum*

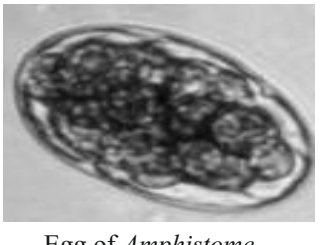


Egg of *Haemonchus contortus*





Egg of *Fasciola*



Egg of *Amphistome*

Egg of *Moniezia expansa*

Floatation Method:-

Requirements

- Fresh or 10 % formalin or 70 % ethyl alcohol preserved faecal sample
- Microcsope
- Glass slide
- Cover slip
- Tooth pick
- Flat bottam test tube
- Dropper
- Saturated salt solution
- Water

Principle:

When parasitic eggs or protozoan cysts are suspended in a liquid with a specific gravity higher than that of the eggs, the eggs will float up to the surface. Nematode and cestode eggs float in a liquid with a specific gravity of between 1: 10 and 1:20. Trematode, which are much heavier, require a specific gravity of 1.30 – 1.35.

Common saturated solution used in floatation technique;-

- Sodium Chloride (Specific gravity- 1.20)
- Sugar- Sucrose (Sp. Gr. – 1.12 – 1.30)
- Zinc sulphate- 30 % (Sp. Gr. – 1.18)
- Magnesium sulphate – 35 % (Sp. Gr. – 1.28)
- Sodium nitrate (Sp. Gr. – 1.36)

Procedure

- About 2.0 g of faces are mixed with 10 – 20 ml of saturated common salt solution (brine) in a small floatation tube.
- Fill the floatation tube upto the tip with solution.
- A clean coverslip or slide is slid sideways over the top of the tube.
- Left about 30 minutes by which time all the eggs would have floated up and touches the coverslip.
- Then coverslip or slide is gently lifted, inverted and examined the fluid film under low power of the microscope.
- This method is not suitable for eggs of trematodes or most cestodes but is useful for the majority of nematode eggs.

Zinc sulphate centrifugal technique

Procedure: -

- Faecal suspension is prepared by mixing one part of a faecal sample and 10 parts of luke warm water.
- About 10 cc. Of the suspension is strained through one layer of wet cheese cloth and filtrate are centrifuge for 2 or 3 times until the supernatant is clear.
- Then sediment is mixed with a saturated solution of Zinc sulphate in a centrifuge tube and then centrifuge for 1 or 2 minutes.
- Eggs will float to surface and then touch the coverslip with the surface of solution.
- Lift the coverslip gently and placed it on a clean slide and examined under a microscope.

This method is suitable for the detection of eggs of cestodes, most of the nematode and oocyst of coccidian.

A. Blood Smear Examination:

For the diagnosis of haemoprotozoan parasites (*Trypanosma*, *Theileria*, *Babesia*, *Hepatozoon* etc.), microfilaria of *Dirofilarial immitis* (heart worm of dog), rickettsial organisms (*Anaplasma*, *Ehrlichia* etc.)

Preparation of blood smear

Requirements:

- Glass slide
- 2% glacial acetic acid in ethyl alcohol
- Distilled water
- Anticoagulants
- Spirit
- Needle

Procedure

Cleaning of slides:

The slides should be hard, non-fogging white glass with no sharp edges. For faecal examination, 25 x 75 mm (regular size) size is used. When making a preparation on a slide, it is most important that the slides should be absolutely grease free and clean. To make it absolutely grease-free the slides are soaked overnight in 2% glacial acetic acid in ethyl alcohol, washed in distilled water, dried and cleaned with dry muslin cloth before use.

Anticoagulants

- **Ethylene diamine tetra acetic acid :** 1 mg of powder to 5 ml of blood.
- **Heparin :** 75 units for 10 ml. of blood.
- **Sodium oxalate 20% :** use @ 0.01 ml/ml of blood.
- **Sodium citrate 25% :** use @ 0.01 ml/ml of blood.

Collection of blood

Small amount of blood for making smears may be taken from the ear vein of horse, cattle, sheep, goat, pig, rabbit and dog. When a blood sample from a bird is required, the vein near the elbow joint under the wing is punctured. The hairs from the area should be clipped and the part cleaned and disinfected with 70% alcohol or methylated spirit.

Thin blood smear

The site of the vein is cleared with non-fluffy cotton and ethyl alcohol to remove the contaminants and the slide is dried. The vein is punctured using a clean needle.

A small drop of blood, less than a pin's head is placed in the middle, near one end of the slide.

The slide is held firmly between the middle finger and thumb of the left hand and another clean slide with straight and smooth edges (spreader slide), is placed on the centre of the examination slide. The lower edge of the spreader slide is held at an angle of 30 to 45 degrees and is drawn up to make contact with the drop of blood and wait until drop of blood flows both end of the spreader slide. Draw the spreader slide away from the blood drop with a smooth rapid movement. This action results in thin and even blood smear. The film is dried by waiving it in the air but rapid drying under sunlight may cause artefacts. The examination slide in this position should be protected from fly, dust, moisture, etc. The identity with respect to its host etc. is recorded on the slide.

Points of a good blood film

- The film should occupy about 1/3 of the length of the slide.
- The greater part of it should consist of a uniform single layer of blood cells.
- The edges of the film should be as unbroken as possible.
- The film should not be so thin to break the continuity of the film.

Wet blood film

A wet blood film is used for the detection of living trypanosomes and microfilaria of filarial worms. Staining in this case is unnecessary because the movement of the trypanosomes make them apparent. The use of phase contrast microscope is

especially useful for this purpose.

Procedure

A drop of blood is placed on a clean slide. The blood is covered with a clean, dry coverslip. The film is then immediately examined under the microscope using the high power objective.

Lymph gland biopsy smear

A lymph node smear is sometimes used in preference to a blood smear, for example during an investigation of theileriosis or even trypanosomiasis. Common lymph node used for biopsy is prescapular.

Procedure

A suitable superficial lymph node is selected and palpated so that the site is fully known. The site is shaved and cleaned with the help of alcohol; punctured by a sterile hypodermic needle and the material is gradually drawn into a clean syringe. The collected lymph fluid is ejected on a clean slide and thick smear is drawn with the help of a spreader.

Fixation of slides

- Fixation helps to preserve the material used for the preparation and also enables it to withstand damage during subsequent staining. Otherwise, the smears wouldddeteriorate, the cells may shrink or stretch due to osmosis or be digested by their own cellular enzymes; the material may also be affected by bacteria or fungi such as moulds. Chemical fixatives like methyl alcohol is used to fix them
- **Methyl alcohol:** This is suitable for blood films/smears. The slide is immersed in methanol for two minutes. If an aqueous stain is to be used, the slides must be dipped in water after fixation.

Procedure

Staining

A carefully stained preparation shows parts of structures well coloured with the dye and other parts faintly coloured. When two stains are used, either separately as in methylene blue and eosin or together as in Giemsa's staining, some parts will be coloured by one dye and other parts by the other e.g. the nuclei of protozoa stained by Giemsa appear red and the cytoplasm blue. Various types of stains and their staining methods are described below :

1. Leishman's stain

This stain has a poor keeping quality in hot climate, so it is better to prepare a fresh stain from the powder every month or so.

Staining procedure

Ten drops of Leishman's stain are poured on the slide, rocked gently, and allowed to act for one minute. Twenty drops of slightly alkaline (pH 7.2) distilled water is added to the slide and is mixed by rocking the slide gently. Ten to 20 minutes are allowed for staining. The slide is washed by stream of distilled water in horizontal position until the smear looks pink. Thereafter, the slide is kept in a vertical position so that it drains and dries. It can be examined under a microscope in oil immersion without a coverslip, however, zero number coverslips can be used if permanent mount is needed. Fixation is not required in Leishman's staining procedure because methyl alcohol is already mixed in Leishman's stain.

2. Giemsa's stain

The stain introduced by Giemsa is a modification of a stain made by Romanowsky who mixed methylene blue and eosin so that three colours red, purple and blue were present in the stained slide. Giemsa's stain is a Romanowsky stain containing methylene blue, eosin, methylene azure, glycerol and methyl alcohol. Nowadays the stain is normally obtained in a concentrated form and requires dilution before use.

Preparation of buffer

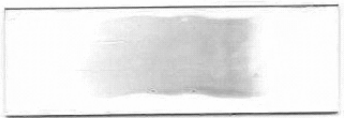
I) KH_2PO_4 (Potassium dihydrogen orthphosphate) - 3.0 gm.
II) $Na_2HPO_4 12H_2O$ (Disodium hydrogen orthophosphate) - 15.0 gm.
Add (i) to half the volume of water, dissolve, then add (ii) and make up to 5 litres, dissolve, mix well and check pH which should be 7.2 and if not, discard and make five litres afresh.

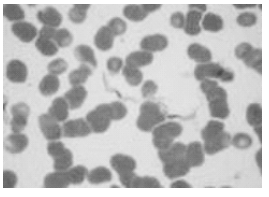
Staining procedure

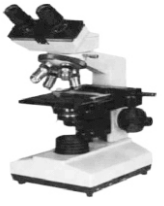
A thin smear is made, allowed to dry thoroughly and fixed in methyl alcohol for two minutes. The stain is diluted with buffer in a ratio of 1:9. The slides are then kept on a staining rack and sufficient diluted stain is poured to cover the smear. It is kept (covered with some tray etc. in summer to avoid evaporation) for 45 minutes. The slides are flooded with buffer/distilled water till the smear is just pink (usually for one minute). The slides are dried in the air and examined under the microscope under oil immersion

The artifacts are liable to camouflage the precision of the microscopic findings. To avoid this, the slides should be placed vertically in the copulin jar having the

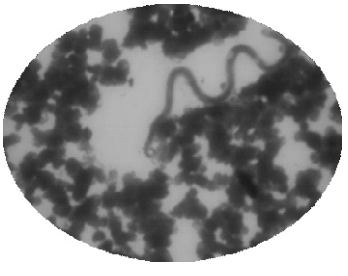
required stain or preferably stained on a horizontal rack, diluted and washed with a buffer in the same position. If the stain is poured off, the scum is liable to stick to the slide and forms artifacts.



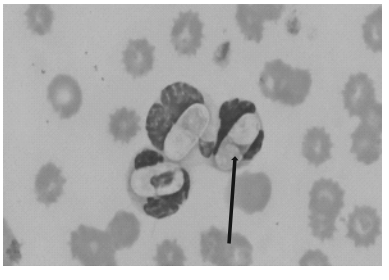




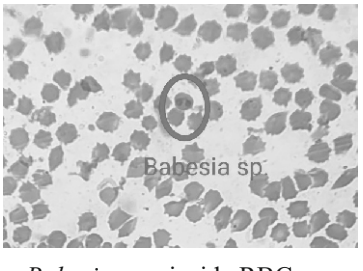
Trypanosoma



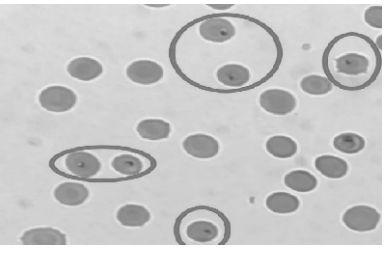
Microfilaria of *Dirofilarial immitis*



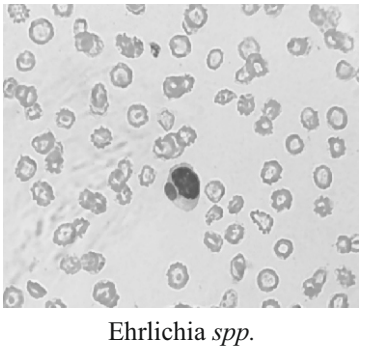
Hepatozoon canis inside neutrophil



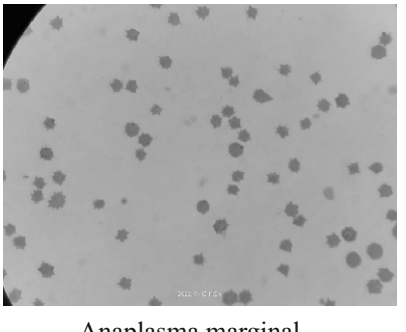
Babesia spp. inside RBCs



Theileria *sp. inside RBCs*



Ehrlichia *spp.*



Anaplasma marginal

C. Skin Scarping Method

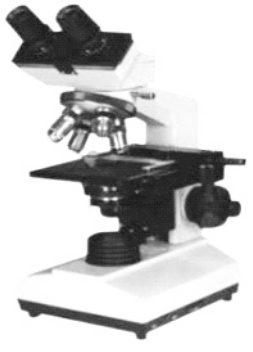
Used for the diagnosis of parasitic mites. Mites causing a disease in animals

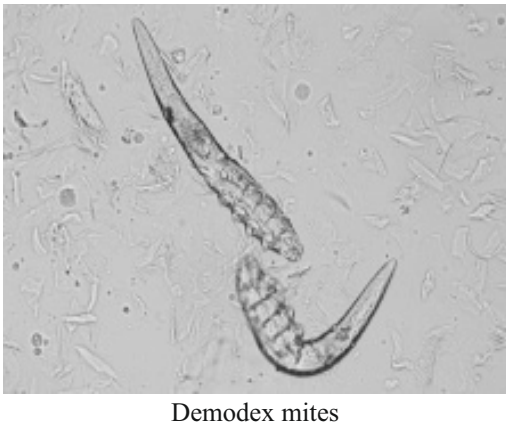
called mange. Mange includes alopecia, dermatitis etc.

Procedure

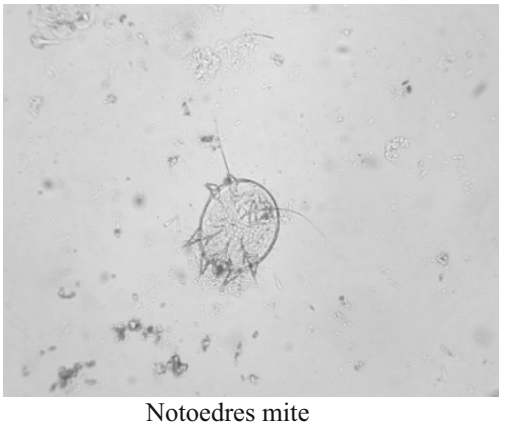
- Clip the hairs around lesion and scrap the edges of skin lesions with the help of a blunt scalpel or blade to extent that a little blood begins to ooze through the abrasions. Collect the scraping materials on a plane paper.
- Skin scrapings should be taken from moist part near the edge of the lesion avoiding the inclusion of large amount of dry crust, hair or wool. It is also desirable to take scrapings from more than one lesions.\
- Boil the scraping materials in 10 percent KOH to dissolve debris.
- After cooling pour the materials into centrifuge tube and centrifuge for 2 minutes at 2000 rpm.
- Take one drop of sediment on a glass slide , cover with cover slip and examine under low power (40X) of microscope for the presence of mites.

Hyperkeratosis of skin





Demodex mites



Notoedres mite

Interpretation of Biochemical Data for Diagnosis and Management of Metabolic Disorder

Ajeet Kumar
Department of Veterinary Biochemistry
Bihar Veterinary College, Patna-14

Case 1: Downer Cow Syndrome (Milk Fever / Hypocalcemia)

Case Description

A 6-year-old crossbred dairy cow was presented 24 hours post-calving with clinical signs of sternal recumbency, cold extremities, and muscle tremors. Physical examination revealed hypothermia, bradycardia, and reduced rumen motility. Based on the clinical presentation and periparturient status, a metabolic disorder was suspected as the underlying cause.

Laboratory Biochemical Data

Parameter	Result	Reference Range	Interpretation
Calcium (mg/dl)	5.8	9.0-11.7	↓ Hypocalcemia
Phosphorus (mg/dl)	2.1	5.6-8.0	↓ Hypophosphatemia
Magnesium (mg/dl)	1.10	1.5-2.9	↓ Marginally low
Sodium (mmol/L)	145	142-152	Normal
Potassium (mmol/L)	3.5	3.6-4.9	↓ Marginally low
Glucose (mg/dl)	38	45-75	↓ Marginally low
AST (SGOT) (U/L)	180	60-125	↑ Muscle damage

Diagnosis

- **Primary Diagnosis:** Hypocalcemia (Milk Fever)
- **Supporting Data:** Low calcium, clinical signs
- **Secondary Findings:** Low phosphorus and borderline low magnesium and potassium can exacerbate neuromuscular symptoms.

Pathophysiology Brief

- High calcium demand post-calving for milk synthesis.
- Delayed PTH response and/or vitamin D activation in older, high-producing cows.

Interpretation of Other Parameters

- Hypophosphatemia often co-occurs and may prolong recovery.
- Low glucose may result from anorexia and poor energy intake.
- Elevated AST could indicate muscle injury due to prolonged recumbency.

Therapeutic Decision Based on Data

- IV administration of calcium borogluconate slowly under cardiac monitoring.
- Oral calcium supplementation to prevent relapse.
- Address phosphorus, magnesium and potassium if needed.
- Supportive care (soft bedding, rolling, and fluid therapy if needed).

Monitoring Response

- Repeat calcium and phosphorus at 12–24 hr intervals.
- Observe improvement in posture, appetite, and muscle strength.

Case 1: Downer Cow Syndrome (Milk Fever / Hypocalcemia)

Case Description: Ketosis in a Dairy Cow

A 5-year-old high-yielding crossbred dairy cow was presented on the 10^{th} day postpartum with signs of inappetence, progressive weight loss, decreased milk yield, and mild depression. The animal exhibited a sweet-acetone-like odor on the breath and ketotic smell in the milk. On physical examination, the cow was alert but dull, with normal temperature and slightly reduced rumen motility. No signs of mastitis or retained placenta were noted.

Laboratory Biochemical Data:

Parameter	Result	Reference Range	Interpretation
Glucose (mg/dl)	35	45-75	↓ Hypoglycemia
β-hydroxybutyrate (BHB) (mmol/L)	2.8	<1.2 mmol/L	↑ Elevated – ketosis
Non-Esterified Fatty Acids (NEFA) (mmol/L)	0.9	<0.4 mmol/L	↑ Excessive fat mobilization

Urine and milk Analysis: Presence of ketone bodies and BHB

Diagnosis

- **Primary Diagnosis:** Clinical ketosis (Type I)
- **Supporting Data:** Hypoglycemia,Presence of ketone bodies in urine, decreased milk yield

Pathophysiology Brief

- Negative energy balance post-calving leads to lipolysis and ketone body formation.
- Liver overload causes accumulation of BHB and NEFA.

Interpretation of Biochemical Data

- Low glucose indicates insufficient energy intake.
- High NEFA shows fat mobilization from adipose tissue.
- High BHB confirms ketosis

Therapeutic Decision Based on Data

- IV glucose (dextrose 50%) or oral propylene glycol as glucose precursors.
- Administration of corticosteroids to stimulate gluconeogenesis.
- High-energy, palatable feed with adequate fiber and protein.
- Monitor for secondary conditions (e.g., displaced abomasum, metritis).

Case 3: Jaundice in a Cow

A 4-year-old non-pregnant crossbred dairy cow was presented with a 5-day history of inappetence, yellowish discoloration of the mucous membranes and sclera, and reduced milk yield. The animal also showed mild depression, dry feces, and occasional abdominal discomfort. On clinical examination, scleral and vaginal

mucosa were icteric, rectal temperature was normal (101.5°F), and rumen motility was slightly reduced.

- There was history of recent calving and haemoglobinuria - Post parturient haemolysis due to phosphorus deficiency
- There was no history of recent calving, haemoglobinuria, high Temperature- Hepatic dysfunction due to Liver fluke infestation
- There was no history of recent calving but history of haemoglobinuria and high Temperature- Hemolytic anemiadue to hemo-protozoan disease

Pathophysiological Insight

Jaundice in cattle can result from:

- **Pre-hepatic causes** (e.g., hemolysis)
- **Hepatic causes** (e.g., hepatitis, toxins, liver flukes)
- **Post-hepatic causes** (e.g., bile duct obstruction)

The elevation in both direct and indirect bilirubin**,** along with high GGT and ALP, supports intrahepatic or post-hepatic cholestasis. Low albumin and protein suggest impaired liver synthetic function.

Laboratory Biochemical Data:

Parameter	Pre-hepatic (Hemolytic)	Hepatic (Hepatocellular damage)	Post-hepatic (Obstructive)
Total Bilirubin	↑↑ (moderate to marked)	↑↑ (Moderate)	↑↑↑ (marked)
Direct (Conjugated) Bilirubin	Normal or mildly ↑	Mild ↑	↑↑↑ (dominant fraction
Indirect (Unconjugated) Bilirubin	↑↑(predominant fraction)	Mild↑	Normal or slightly ↑
AST (SGOT)	Mild to moderate ↑	↑↑↑ (due to hepatocellular injury)	Normal or mild ↑
GGT (Gamma - glutamyl transferase)	Normal or slightly ↑	↑↑ (moderate to marked)	↑↑↑ (highly elevated due to cholestasis)

Parameter	Pre-hepatic (Hemolytic)	Hepatic (Hepatocellular damage)	Post-hepatic (Obstructive)
ALP (Alkaline Phosphatase)	Normal or mild ↑	Normal or mild ↑	↑↑↑ (cholestatic marker, bile duct obstruction)
Serum Albumin	Normal	↓↓ (impaired synthesis)	↓ (in prolonged cases)
Total Protein	Normal	↓	Normal to ↓
Urine Colour	Normal to dark yellow	Yellow to brownish	Coffee colour or dark brown
Feces Colour	Normal to dark (due to increased urobilinogen)	Normal	Clay-colored or pale (lack of bile pigment)
Blood smear examination	Positive for hemo-protozoan	Negative	Negative
Faecal examination	Negative	Positive for liver flukes	May be Positive for liver flukes

Case 4: Diabetes in Dog

A dog was presented to the clinic with a three-week history of progressively increasing water consumption and urination. According to the owner, the dog has also exhibited a marked increase in appetite (polyphagia) but is experiencing noticeable weight loss despite an adequate food intake. Additionally, the dog appears lethargic and has begun having occasional indoor accidents, which is uncharacteristic of its usual behaviour.

Observed Clinical Signs:

- Polyuria and polydipsia (PU/PD)
- Polyphagia with weight loss
- Mild lethargy
- Possible cloudiness in eyes (suspected cataracts)
- No vomiting, diarrhea, or acute illness
- No recent changes in diet, medication, or environment

Laboratory Biochemical Data:

Parameter	Result	Reference Range	Interpretation
Glucose (Fasting) (mg/dl)	362	75–120	↑ Marked hyperglycemia
HbA1c (Glycated Hemoglobin)	8.1 %	3.0%–4.5%	↑ Marked long term hyperglycemia
ALT (U/L)	190	10–125	↑ Mild hepatocellular leakage
ALP(U/L)	420	20–150	↑↑ Likely steroid-induced or cholestasis
Cholesterol	145	142-152	↑ Hyperlipidemia (secondary)
Potassium (mmol/L)	3.5	3.6-4.9	↓ Marginally low
Glucose (mg/dl)	38	45-75	↓ Marginally low
AST (SGOT) (U/L)	180	60-125	↑ Muscle damage
Glucose in urine	+++	Normally absent	Glycosuria
Ketone bodies in urine	May be present	Normally absent	Ketonuria (diabetic ketosis)
Protein	Trace	Normally absent	Possibly due to tubular stress

Pathophysiology

- Insulin deficiency → impaired glucose uptake → hyperglycemia
- Glucose exceeds renal threshold →glycosuria → osmotic diuresis → Polyuria and polydipsia
- Weight loss despite polyphagia: body shifts to catabolism for energy
- Hepatic enzyme elevation (esp. ALP) due to stress, hepatomegaly, or concurrent hyperadrenocorticism
- Hyperlipidemia due to altered fat metabolism

Therapeutic Approach

- Start insulin therapy: Intermediate-acting (NPH or lente)
- Feed high-fiber, complex carbohydrate diet, timed with insulin
- Encourage regular mild exercise
- Educate owner on home monitoring of water intake, appetite, and urine output

Common Clinical Cases at Veterinary Medicine OPD at VCC

Vivek Kumar Singh and Pallav Shekhar
Dept. of Veterinary Clinical Complex
Bihar Veterinary College, Patna-14

Section I: Canine Clinical Cases

1. Canine Babesiosis

Etiology & Pathophysiology: Protozoal infection of erythrocytes by *Babesia* spp.—especially *B. canis*, *B. gibsoni*. Intraerythrocytic replication leads to hemolytic anemia and systemic inflammation

Clinical Signs: Fever, pale/icteric mucous membranes, weakness, splenomegaly, hemoglobinuria ("red-water" urine), thrombocytopenia, possible shock in severe cases

Diagnostics: Peripheral blood smear (Maltese cross rarely seen); PCR and serology for species ID in low-parasiticemia

Treatment:Imidocarbdipropionate or combination **atovaquone–azithromycin**; supportive fluids and, if needed, transfusions

2. Canine Ehrlichiosis

Etiology: *Ehrlichiacanis* infects monocytes; vector-borne via *Rhipicephalussanguineus* (brown dog tick)

Clinical Presentation:

Acute phase: Fever, lymphadenopathy, splenomegaly, thrombocytopenia, anorexia, depression, ocular/nasal discharge

Chronic phase: Weight loss, edema (limbs/scrotum), bleeding tendencies, respiratory distress, immunosuppression

Diagnostics: CBC (pancytopenia + thrombocytopenia), blood smear, SNAP 4Dx, PCR, or IFA serology.

Treatment:Doxycycline (10 mg/kg PO daily for 4 weeks); supportive care for bleeding/coagulopathies.

3. Canine Distemper (CD)

Etiology: Caused by **Canine Distemper Virus (CDV)**, a **morbillivirus** in the family *Paramyxoviridae*.

Affects domestic dogs and wild carnivores.

Spread via aerosol droplets and contact with secretions; virus is shed in all excretions

during active infection.

Pathophysiology:

CDV has **lymphotropic** and **neurotropic** properties.

Initially infects respiratory epithelium → spreads to lymphoid tissue → viremia → systemic dissemination.

Involves **respiratory**, **gastrointestinal**, **integumentary**, and **central nervous systems**.

Causes **immunosuppression**, predisposing to secondary infections.

Clinical Signs

1. Systemic (Early) Signs:

Biphasic fever (initial mild fever followed by a higher second fever)

Lethargy

Anorexia

Serous to mucopurulent nasal discharge

Serous to mucopurulent ocular discharge

Coughing

Dehydration

2. Respiratory Signs:

Cough (dry or moist)

Dyspnea (difficulty breathing)

Bronchopneumonia due to secondary bacterial infections

3. Gastrointestinal Signs:

Vomiting

Diarrhea (may be watery or mucoid)

Weight loss

4. Neurological Signs*(may occur weeks after initial signs):*

Myoclonus (rhythmic twitching, especially of head or limbs)

Seizures ("chewing gum fits" – jaw clenching with drooling)

Ataxia (incoordination)

Paresis or paralysis

Behavior changes, depression

Head tilt, circling

Nystagmus, blindness

5. Dermatologic Signs:

Hyperkeratosis (thickening) of nose and footpads – "hard pad disease"

Crusting of nose, paw pads, and sometimes periorbital areas

6. Ocular Signs:
Conjunctivitis
Keratitis
Chorioretinitis
Optic neuritis
Uveitis
Retinal detachment in severe cases

7. Dental Signs in Puppies:
Enamel hypoplasia (if infected during tooth development phase)

Diagnosis:
Presumptive: Clinical signs + history (especially in unvaccinated dogs).

Definitive:
RT-PCR on conjunctival/nasal swabs or blood.
Immunofluorescence on conjunctival scrapings or CSF.
Serology: CDV antibody titers (paired samples).

Differential Diagnoses:
Infectious canine hepatitis
Kennel cough
Lead poisoning
Rabies
Toxoplasmosis

Treatment:
Supportive and symptomatic:
Broad-spectrum antibiotics to prevent/treat secondary infections (e.g., amoxicillin-clavulanate)
Anti-inflammatory drugs (e.g., meloxicam)
Anticonvulsants (e.g., phenobarbital for seizures)
Fluid therapy (Ringer's lactate or DNS)
Nutritional support, warmth, and nursing care
No specific antiviral drug is curative.

Prognosis
Variable: Guarded in severe neurological cases.
Survivors may have permanent neurologic deficits or enamel hypoplasia.
Prevention
Vaccination is the cornerstone.
Start at 6–8 weeks; booster every 3–4 weeks until 16 weeks.
Annual or triennial boosters thereafter.
Avoid exposure to infected animals.
Disinfection with phenol or quaternary ammonium compounds (CDV is susceptible to heat, UV light, and disinfectants).
Canine Parvo Viral Enteritis (CPV)

Etiology
Caused by **Canine Parvovirus type 2 (CPV-2)**, a highly contagious **non-enveloped DNA virus**.
Primarily affects puppies between **6 weeks to 6 months**.
Spread via **fecal-oral route**; virus is highly resistant in the environment and survives for months.

Pathophysiology
CPV targets **rapidly dividing cells**, especially:
Crypt epithelial cells of the small intestine → villous atrophy → hemorrhagic diarrhea.
Bone marrow precursors → leukopenia, neutropenia → immunosuppression.
In neonatal pups, may also affect myocardium → **myocarditis** (now rare).

Clinical Signs
Sudden onset of: Hemorrhagic, foul-smelling diarrhea
Projectile vomiting
- Anorexia, dehydration, lethargy
- Fever or hypothermia
- Pale mucous membranes
- Abdominal pain

Death may occur within 2–3 days in severe untreated cases.
Diagnosis:
Presumptive: Based on age, vaccination history, signs.
Definitive:
Fecal ELISA antigen test (fast, widely used)

PCR for virus DNA (sensitive)
CBC: Leukopenia, neutropenia, elevated PCV/TP if dehydrated
Serum biochemistry: Hypoglycemia, hypokalemia, prerenal azotemia

Differential Diagnoses
Canine coronavirus
Salmonellosis
Campylobacteriosis
Hemorrhagic gastroenteritis
Foreign body
Treatment:
Aggressive supportive therapy is key:
IV fluids: Ringer's lactate with dextrose & potassium supplement
Antibiotics: Broad-spectrum (e.g., cefotaxime, metronidazole) to prevent sepsis
Antiemetics: Ondansetron or maropitant
Gastroprotectants: Sucralfate, ranitidine
Nutritional support: Early enteral feeding improves recovery
Monitoring: Electrolytes, hydration status, blood glucose

Prognosis
With prompt and appropriate treatment: survival >85%
Without treatment: mortality >90%
Guarded prognosis in neonates and severely immunocompromised dogs

Prevention
Core vaccination.
Begin at 6–8 weeks, then every 3–4 weeks until 16–20 weeks.
Booster at 1 year, then every 3 years.
Environmental disinfection with bleach (1:30 dilution) or accelerated hydrogen peroxide.

Ruminant Clinical Cases
1. Bovine Anaplasmosis
Etiology & Transmission:*Anaplasmamarginale* infects erythrocytes; transmitted by ticks, biting flies, dirty needles; chronic carriers are main reservoir
Pathogenesis & Clinical Signs: Progressive extravascular hemolytic anemia, fever, rapid pulse, pale → icteric mucous membranes; urine normally not discolored; high mortality in adult cattle

Presentation by Age
<1 year: typically subclinical
1–2 years: moderate disease
3 years: acute to peracute presentations, often fatal

Diagnostics: Blood smear (inclusions), PCR, serology. Carrier animals require sensitive assays.
Treatment & Control: Oxytetracycline (22 mg/kg IM); supportive transfusion in severe cases. Control via vector management and management of carrier animals

2. Babesiosis
Etiology: *Babesiabovis* and *B. bigemina* transmitted by ixodid ticks; intraerythrocytic multiplication causing hemolysis
Clinical Signs: High fever, severe anemia, jaundice, hemoglobinuria, red-water, "cerebral babesiosis" from capillary sludging
Diagnosis: Blood smears—visualizing trophozoites; PCR/IFA for species identification.
Treatment: Imidocarbdipropionate or diminazene; fluids, antipyretics, controlling secondary infections

3. Theileriosis
Etiology:*Theileriaannulata* or *T. parva*; schizonts in lymphoid cells; transmitted via ticks.
Clinical Signs: Fever, lymphadenopathy (especially parotid, pre-scapular), anorexia, anemia, respiratory distress.
Diagnostics: Lymph node biopsy with Giemsa-stained smears; PCR.
Treatment: Buparvaquone (2.5 mg/kg IM); supportive oxytetracycline, NSAIDs; tick control essential.

4. Lumpy Skin Disease (LSD)
Etiology: Capripoxvirus; transmitted through flies, mosquitoes, possibly ticks.
Clinical Presentation: Firm nodules on skin, mucous membranes, udders; fever, lymphadenopathy, lacrimation.
Diagnosis: Clinical signs + PCR confirmation.
Treatment: Supportive (NSAIDs, antibiotics for secondary infections), ensure good nursing care; vaccination recommended for control.

Clinical Cases of Goat

1. Peste des Petits Ruminants (PPR)

Etiology: Morbillivirus affecting goats/sheep; high morbidity/mortality.

Clinical Signs: Fever, ocular/nasal discharge, stomatitis, necrotic oral lesions, respiratory signs, hemorrhagic diarrhea.

Diagnosis: RT-PCR of swabs, FA or ELISA.

Treatment: Supportive (fluids, broad-spectrum antibiotics); outbreak control via vaccination and quarantine.

2.Orf (Contagious Ecthyma)

Etiology: Parapoxvirus; affects young goats.

Clinical Signs: Papules → pustules → scabbed lesions on muzzle, teats, feet.

Diagnosis: Clinical; confirm via electron microscopy or PCR if needed.

Treatment: Self-limiting within 4–6 weeks; topical antiseptics; isolate affected animals to prevent spread while environmental virus persists long-term.

3. Thiamine Deficiency (Polioencephalomalacia)

Etiology: Thiamine deficiency in goats, often due to ruminal microflora alterations; leads to cerebrocortical necrosis.

Clinical Signs: Depression, blindness, head-pressing, opisthotonus, nystagmus, cortical seizures.

Diagnosis: Based on clinical signs and rapid response to thiamine therapy; CSF may show elevated lactate.

Treatment: Thiamine HCl 10 mg/kg IM q8 h for 3 days, taper per response. Supportive treatment is vital.

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Suture and Suturing Techniques in Veterinary Practice

Gyan Dev Singh
Veterinary Clinical Complex
Bihar Veterinary College, Patna-800014.

Definition of Suturing

Suturing is the process of **approximating tissues using sterile thread-like materials (sutures)** to facilitate healing and restore anatomical continuity after injury or surgery.

Objectives of Suturing

- Achieve **hemostasis**
- Promote **primary wound healing**
- Minimize **infection and inflammation**
- Maintain **tissue strength and function**
- Provide **aesthetic closure** where necessary

Factors Affecting Suturing

Characteristic	Description
Biocompatibility	Non-toxic, non-carcinogenic, minimal tissue reaction
Tensile Strength	Adequate strength to hold tissues until healing occurs
Knot Security	Holds knots firmly without slipping or untying
Handling Properties	Easy to pass through tissue, flexible, minimal memory
Minimal Tissue Reaction	Should not provoke inflammation or hypersensitivity
Predictable Absorption	For absorbable sutures –known rate of degradation aligned with healing
Sterilizable	Must be capable of sterilization without degradation
Economical & Available	Cost-effective and easily accessible in field or clinic

Characteristics of an Ideal Suture Material

An ideal suture should:

Factor	Influence on Suturing Outcome
Wound Type & Location	Determines suture technique and material; e.g., facial wounds require finer sutures
Tension on Wound Edges	Excess tension causes dehiscence or necrosis; must select tension-bearing suture patterns
Tissue Type	Fragile tissues (e.g., liver, bladder) need atraumatic needles and fine sutures
Patient Factors	Age, nutrition, systemic diseases (e.g., diabetes) affect healing capacity
Suture Technique Used	Interrupted vs. continuous; everting vs. inverting affects tissue apposition
Sterility & Aseptic Conditions	Poor asepsis can lead to infection, dehiscence
Skill of the Surgeon	Proper needle angle, depth, and knot technique are crucial for success

TYPES OF SUTURE MATERIAL

Classification of Suture Materials

A. Based on Absorbability

Type	Characteristics	Examples
Absorbable	Broken down and absorbed by the body over time via enzymatic or hydrolytic action	Catgut, Vicryl, Dexon, PDS
Non-Absorbable	Permanently retained unless removed; used where long-term support is needed	Silk, Nylon, Prolene, Stainless steel

B. Absorbability:

Type	Characteristics	Examples
Monofilament	Single strand; less tissue drag; resists infection	Nylon, Prolene, PDS
	Multiple fibers twisted or braided; better handling, more tissue reaction	Silk, Vicryl, Dexon

2. Absorbable Suture Materials

A. Catgut (Plain & Chromic)

Origin: Natural (sheep intestine)

Absorption: Enzymatic (complete in 7–10 days for plain; 21–28 days for chromic)

Uses: Ligation, subcutaneous closure

Disadvantage: High tissue reaction, unpredictable strength loss

B. **Polyglactin 910 (Vicryl)**

Type: Synthetic, braided

Absorption: By hydrolysis, complete in 56–70 days

Advantages: Predictable strength loss, minimal tissue reaction

Uses: General soft tissue approximation, including muscle and subcutis

C. **Polyglycolic Acid (Dexon)**

Type: Synthetic, braided

Absorption: Hydrolytic, ~90 days

Uses: Similar to Vicryl; useful in intestinal and bladder surgeries

D. Polydioxanone (PDS)

Type: Synthetic, monofilament

Absorption: 180+ days (slow)

Uses: Fascia, tendons, long-term support tissues

Advantages: Strong, low tissue reaction

3. Non-Absorbable Suture Materials

A. **Silk**

Type: Natural, braided

Tissue Reaction: High

Use: Cardiovascular, ophthalmic, ligatures

Disadvantage: Can act as a nidus for infection

B. Nylon (Ethilon, Dermalon)

Type: Synthetic, monofilament

Properties: High tensile strength, minimal reaction

Uses: Skin closure, orthopedic repairs

C. Polypropylene (Prolene)

Type: Synthetic, monofilament

Properties: Inert, excellent tensile strength

Uses: Cardiovascular, skin, plastic surgeries

D. Polyester (Dacron, Mersilene)

Type: Synthetic, braided or coated

Use: Tendon repair, orthopedic surgeries

Caution: May saw through tissue

E. Stainless Steel

Type: Monofilament or twisted

Use: Orthopedic surgery, sternum closure, herniorrhaphy

Advantages: Maximum strength, inert

Drawbacks: Poor handling, kinks easily

4. Suture Size System

USP Size Diameter (approx.)	Common Use
0 – 2 Large size	Tendons, ligaments, large vessels
2-0 to 4-0 Medium	Skin, fascia, subcutis
5-0 to 7-0 Fine	Ophthalmic, microvascular

5. Suture Material Selection

Tissue Type	Recommended Suture
Skin	Nylon, Prolene (non-absorbable)
Subcutis	Vicryl, Dexon (absorbable)
Muscle	Vicryl, PDS
Bladder/Intestine	Vicryl, PDS (rapidly absorbable)
Fascia	PDS, Prolene (high tensile, delayed absorbable)
Tendon	Prolene, Polyester, Stainless steel

DIFFERENT TYPES OF SURGICAL KNOTS

1. Definition of Surgical Knot

A **surgical knot** is a method of securing suture material during or after wound closure to maintain **tissue approximation**, hemostasis, and stability.

2. Essential Qualities of a Good Surgical Knot

Secure and firm

Minimal tissue trauma

Easy to tie and adjust

Resistant to slippage

Does not loosen with tension

3. Common Types of Surgical Knots

Knot Type	Description	Application
Simple Knot	A single half-hitch; insecure if used alone	Starting point; must be followed by more throws
Square Knot	Two opposite half-hitches (right over left, then left over right)	Most commonly used in surgery
Surgeon's Knot	First throw is a double half-hitch, second is a single (e.g., double overhand)	Provides more friction; used under tension
Granny Knot	Two identical half-hitches (e.g., right over right)	Tends to slip; not recommended for final knots
Sliding Knot	Knot can be tightened by pulling ends	Used in laparoscopy, deep tissue where tight space
Ligature Knot	Secure ligation of blood vessels or pedicles; square or surgeon's variant	Hemostasis in vascular or organ ligation
Miller's Knot	Friction knot with a locking loop; secure on large pedicles	Common in large animal ovariectomy
Aberdeen Knot	Self-locking finishing knot for continuous sutures	Quick closure of continuous sutures

4. General Rules for Knot Security

Use **at least 3 throws** for monofilament and **4–5 for multifilament** sutures.

Avoid excessive tension that may cause **tissue necrosis** or **suture breakage**.

Ensure **flat, even knot placement** to minimize irritation and slippage.

Wetting synthetic sutures improves **knot tying** and **grip**.

SUTURE PATTERNS

1. Classification of Suture Patterns

A. Based on Tissue Effect

Type	Effect on Tissue Edges	Purpose
Appositional	Brings tissue edges edge-to-edge	Ideal for skin, fascia, intestine
Everting	Rolls tissue edges outward	Used in skin or tension-bearing areas
Inverting	Rolls tissue edges inward	Used in hollow organs to reduce leakage
Special	Combines functions or used in specific situations	Deep layers, cosmetic closure

2. Appositional Suture Patterns

Pattern	Type	Use
Simple Interrupted	Interrupted	Skin, muscle, fascia
Simple Continuous	Continuous	Skin, subcutaneous, intestines
Cruciate	Interrupted	Skin closure in large animals
Ford Interlocking	Continuous	Skin in large animals, better strength
Subcuticular/Intracutaneous	Continuous	Cosmetic skin closure

3. Everting Suture Patterns

Pattern	Type	Use
Vertical Mattress	Interrupted	Skin under tension; strong eversion
Horizontal Mattress	Interrupted	Skin, especially in areas of high tension
Near-Far-Far-Near	Interrupted	Deep wounds, high tension

4. Inverting Suture

Pattern	Type	Use
Lembert	Interrupted/Cont.	Intestinal and hollow viscera closure
Cushing	Continuous	Serosa and submucosa of hollow organs
Connell	Continuous	Full-thickness hollow organ closure (caution)
Halsted	Interrupted	Intestinal, layered closure
Parker Kerr	Continuous	Used to invert stump of hollow organs

5. Special Suture Patterns

Pattern	Purpose
Purse String	Circular tightening – anus, stomach, catheter sites
Stent Suture	Distributes pressure – used with drains
Chinese Finger Trap	Secures tubes like catheters or drains
Locking Loop	Used in tendon repair
Bunnell/Mayo Mattress	Deep tendon or ligament repair

6. General Tips for Pattern Selection

Use **appositional patterns** for skin, muscle, and fascia.

Use **inverting patterns** for **viscera (intestine, bladder, uterus)** to minimize leakage.

Everting patterns are best where **tension** is present and in **skin closures**.

Interrupted sutures allow precise tension control and security.

Continuous sutures are faster and provide better sealing but less secure if one part fails.

Clinical Tip: Always match suture pattern with **tissue type, healing capacity**, and **functional need** of the surgical site.

Suture Materials Classification and Suture techniques

Mithlesh Kumar
Department of Veterinary Surgery and Radiology
Bihar Veterinary College, Patna-800014.

Classification of suture materials

i) Absorbable:-

-They are organic in nature and absorbed into body tissues after a variable period of time. - Absorption takes place by pathogenesis and enzymatic reaction.
-Close the internal organs or inside the body
-eg. Catgut, fascia lata, Polyglactan 910 (vicryl) polyglycolic acid (Dexon) etc.

ii) Non-absorbable:-

- Not absorbed into body tissues.
- Organic, inorganic or synthetic in nature
- External suture material

Organic

i)Cotton
ii) Silk
iii)Silk worm gut
iv) Umbilical Tape

Inorganic

i) Metallic suture
ii) Suture wire
iii) Stainless steel wire
iv) Pin suture

Synthetic

i) Nylon
ii) Terelene
iii) Polyster
iv) Synthetic mesh

Absorbable

I) Catgut: obtained from the submucosa of small intestine of sheep
- Used as absorbable suture material

- Coated with chromic acid to delay the absorption time

II) Polyglactin 910 (vicryl) : Synthetic absorbable suture material, prepared from glycolic lactic acid
polymer.
- Remains stable in contaminated wound

III) Polyglycolic acid (Dexon): Synthetic suture material
- Prepared from glycolic acid
- Smooth, strong and absorbable

Non Absorbable suture materials:
I) Cotton: Less irritating than catgut, silk and linen, stable to sterilization
- being capillary in nature and spread infection in wound
II) Silk:- Capillary in nature
- does not cause severe tissue reaction
III) Silk worm gut:-obtained from the silk sac of silk worm
- Smooth, strong, non-capillary and useful in cutaneous suture
IV) Linen:- Capillary in nature and produces more tissue reaction than cotton and silk

In organic suture materials
I) Metallic suture:-
- tantalum wire, silver wire, copper wire, stainless steel wire
- Used external and internal suture materials.
II) Tantalum:- inert to tissues like stainless steel
III) Silver:- ionized in tissues and cause inflammation
IV) Copper:- More suitable to repair fracture
V) Aluminium wire:-more flexible than stainless steel wire

3) Synthetic suture Marerial
I) Nylon:-smooth flexible and less irritating to tissues
II) Terelene: Strong, synthetic and easily sterilised
III) Polyster:- Synthetic braided suture derived from ethylene glycol and terephthalic acid
IV)Synthetic mesh: Dacron and nylon meshes are used to fill defects in abdominal wall in cases of hernia and injury

Suture Technique
Classified as
1) Apposition suture:- is used for apposition of wound edges. Ex.Skin, muscles,

esophagus etc. e.g. Simple interrupted, simple continuous, lock stitch and subcuticular suture

3) Inversion suture:-Edges of wound are inverted and brought together. These are used in intestine, uterus etc like hollow visceral organs. These type of wound are preventing leakage.

a) Lembert,s suture:- Suture passes through serous and muscular layer not the mucosal layer.The needle bites at right angle to the suture line.

b) Czerny's suture:- Double row of lumbert suture, one row is buried by the other.

c) Jobert's suture: Like lumbert's suture. Penetrates the all layer but chance of infection.

d) Cushing suture:- Almost similar to lembert's suture but suture line is parallel to the line of incision

E) Connel suture:- Needle penetrates all the layer including mucosa layer.

3) Eversion suture:- Edges are everted and used to suture the cut end of vessels

4) Purse-string suture:- This is used to narrow the lumen of hollow organ and used in rectal prolapse to reduce the anal opening.

Miscellaneous suture:-

a) Horizantal mattress
b) Vertical mattress
c) Cross suture
d) Overlapping suture or vest overpant suture

Ultrasound-Guided Reproductive Examination in Bovines

Sumit Singhal and Alok Kumar
Department of Veterinary Gynaecology and Obstetrics
Bihar Veterinary College, Patna-800014.

Abstract

Ultrasonography has become an indispensable diagnostic and research tool in veterinary reproduction, particularly in the reproductive examination of bovines. The non-invasive, real-time imaging capability provides accurate information on ovarian structures, uterine status, early pregnancy diagnosis, fetal viability, and various pathological conditions. This comprehensive article explores the technical principles, instrumentation, procedural methodologies, sonographic interpretation, and practical applications of ultrasound-guided reproductive examination in bovines. Emphasis is laid on the integration of ultrasonography into clinical and field fertility management programs, including estrus synchronization, embryo transfer, OPU-IVF programs, and diagnosis of reproductive pathologies. The manuscript also highlights advancements, constraints, and future perspectives in this evolving field.

1. Introduction

Bovine reproduction forms the cornerstone of livestock productivity, particularly in dairy and beef industries. Traditional reproductive examination relies on per rectal palpation; however, ultrasonography has significantly enhanced diagnostic precision and allowed for dynamic evaluation of reproductive organs. The integration of ultrasonography in routine fertility assessment, postpartum evaluation, early pregnancy diagnosis, and advanced reproductive technologies like embryo transfer (ET) and ovum pick-up (OPU) has revolutionized reproductive management. This chapter addresses the theoretical and practical aspects of ultrasound-guided reproductive examinations and elaborates on its clinical applications in bovines.

2. Principles of Ultrasonography

Ultrasonography utilizes high-frequency sound waves (2–15 MHz) generated by piezoelectric crystals. These sound waves are emitted by a transducer and reflected back from tissue interfaces, producing real-time two-dimensional (B-mode) images. The nature of the echo depends on tissue density, fluid content, and structural homogeneity. The principle components include:

- **Acoustic Impedance**: Determines the reflection of ultrasound waves at tissue boundaries.

- **Attenuation**: Reduction of wave intensity with tissue depth; important for probe selection.
- **Resolution**: Higher frequency = better resolution, lower penetration; lower frequency = deeper penetration.

Transducers used in bovine reproductive work are typically linear or convex rectal probes with a frequency of 5–7.5 MHz.

3. Equipment and Setup

3.1 Ultrasound Machine:

- Portable real-time B-mode scanner
- Rectal linear/convex probe
- Power source or battery-operated unit

3.2 Accessories:

- Shoulder-length gloves
- Lubricants
- Ultrasound gel
- Protective sheath for probe

3.3 Pre-scan Preparation:

- Restrain animal in travis
- Tie tail and evacuate rectum
- Lubricate probe and hand
- Calibrate depth and gain on ultrasound unit

4. Ultrasonographic Technique in Bovine Reproduction

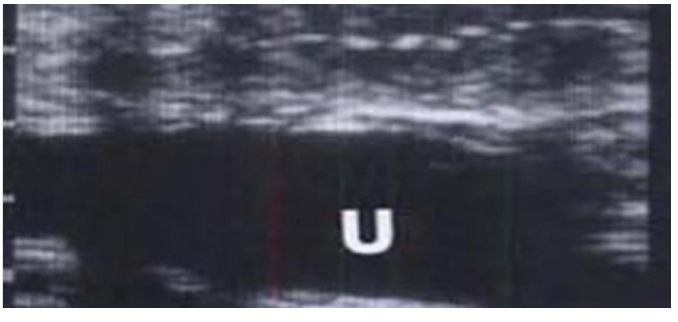
4.1 Transrectal Scanning Procedure

- Introduce gloved and lubricated arm per rectum
- Locate urinary bladder, cervix, uterus, and ovaries by palpation
- Gently place the probe dorsally against the target organ
- Adjust machine settings for optimal visualization

4.2 Identification of Reproductive Structures

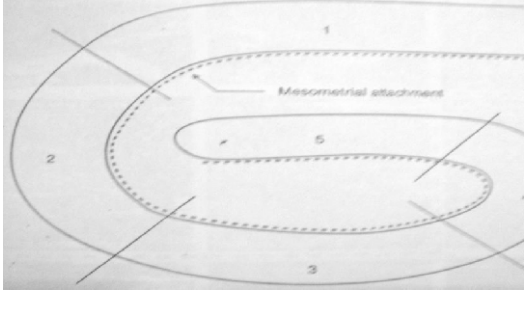
Urinary Bladder:

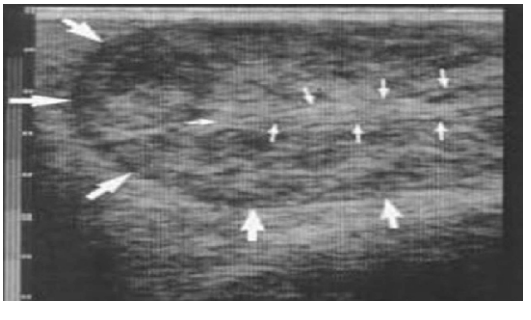
- Although not the part of reproductive organ
- Due to its easy visibility act as landmark during sonography of reproductive organs



Uterus:

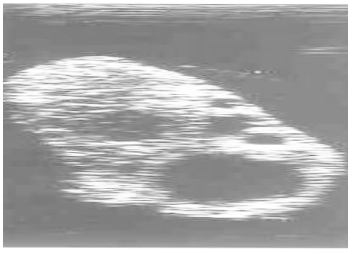
- Non-pregnant: tubular, uniform echogenic wall
- Pregnant: fluid-filled horn with hypoechoic content



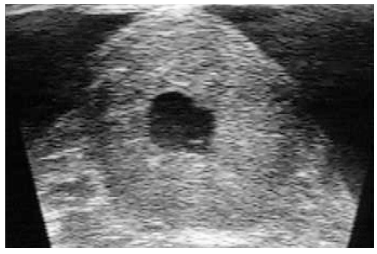


Ovaries:

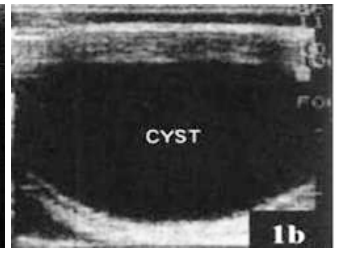
- Follicles: Anechoic (black), round, 3–20 mm
- CL: Mixed echogenicity; central cavity in early luteal phase
- Cysts: Thin-walled, large (>25 mm), anechoic or hypoechoic



Follicles- Black

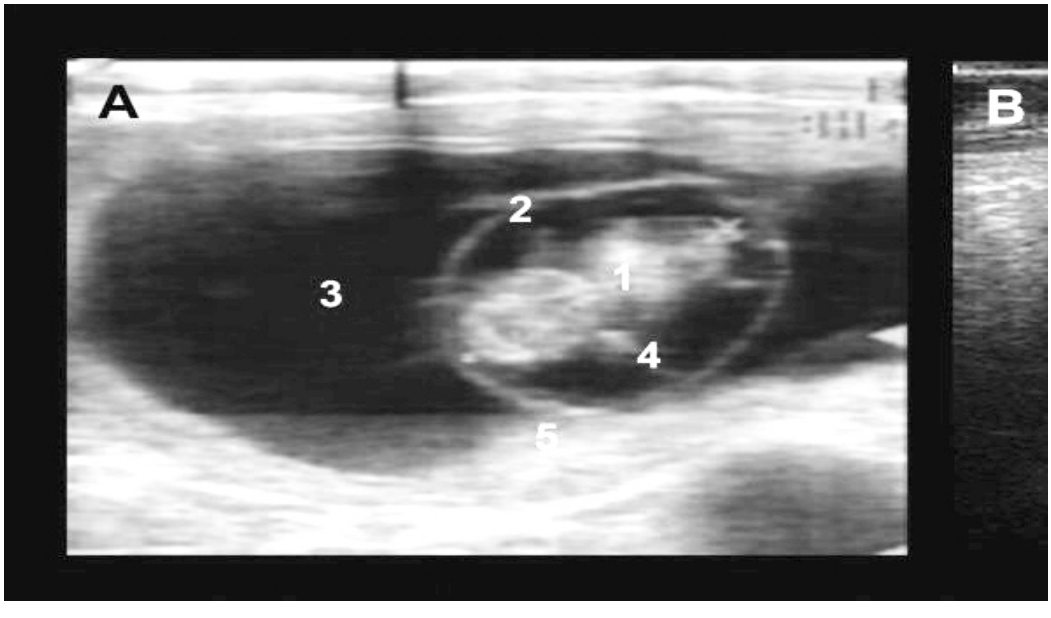


Mature CL with Central cavity



Follicular Cyst

Pregnancy Diagnosis:



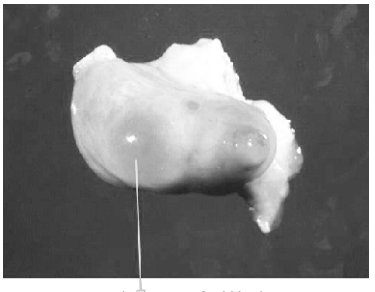
- Day 25: Anechoic embryonic vesicle
- Day 30–35: Embryo with heartbeat
- Day 45–60: Limb buds and placentomes visible

5. Main Field Applications of USG in Large Animal Reproductive Management

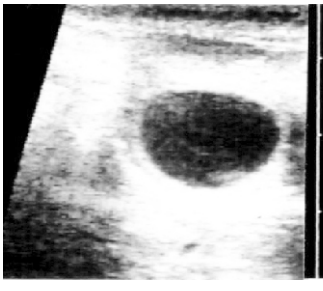
5.1 Estrus Detection and Synchronization Monitoring

- Follicular growth can be monitored, size of about 15-16 mm in absence of CL indicate the preovulatory follicle. Uterine tone and turgidity indicated by presence of vascularity are also seen during estrus.

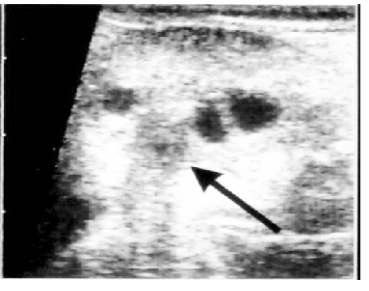
- Confirmation of ovulation – absence of preovulatory follicle in second consecutive sonography at 12-24 h interval.



Pre-ovulatory follicle



Pre-ovulatory follicle

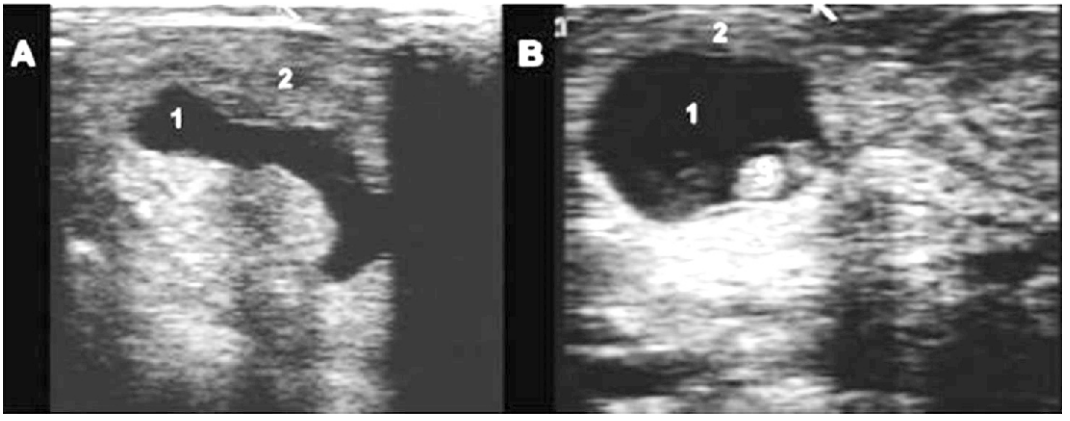


12 hours later, Ovulation has occurred

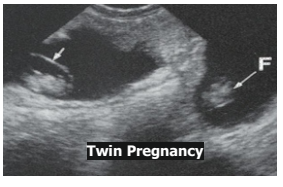
5.2 Early Pregnancy Diagnosis

- Accurate from Day 25–28 post-AI
- Heartbeat, limb movement, crown-rump length measurement
- Differentiation from pseudopregnancy, mucometra
- Detecting twins

Differential diagnosis of mucometra (A) & early pregnancy (B)
(7.5 MHz; depth 5 cm)

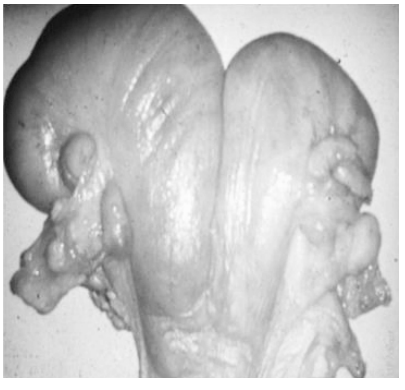


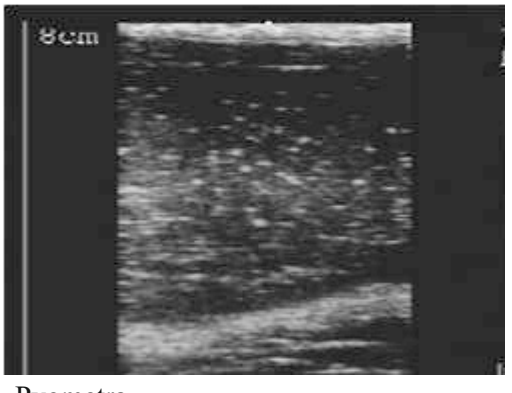
1: Accumulation of clear anechogenic content 2: Uterine wall 3: Embryo



5.3 Diagnosis of Reproductive Pathologies

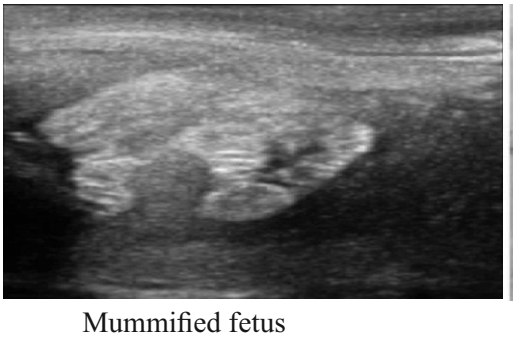
- Pyometra: Echogenic fluid with debris in uterine lumen
- Mucometra/Hydrometra: Anechoic fluid without debris



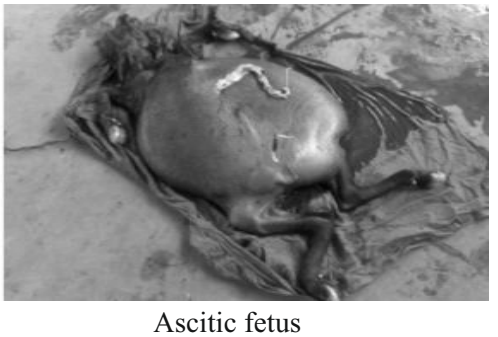


Pyometra

- Mummified fetus
- Fetal ascites

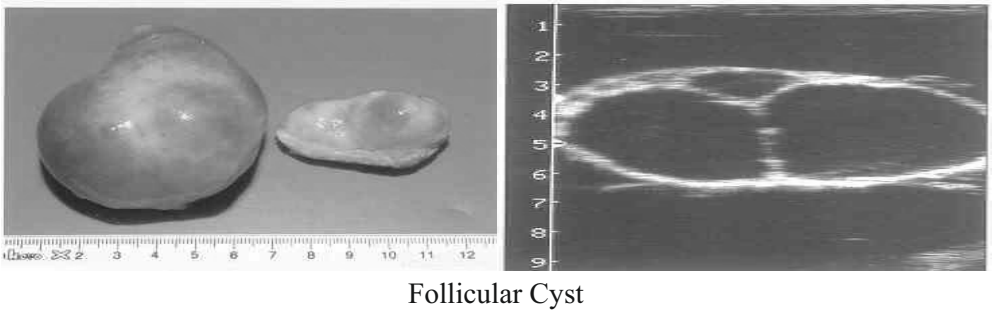


Mummified fetus

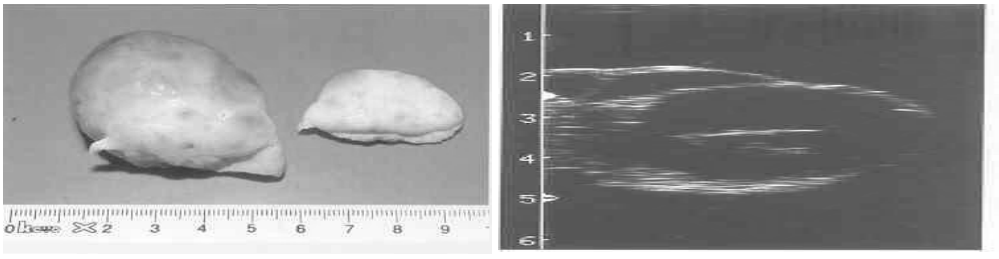


Ascitic fetus

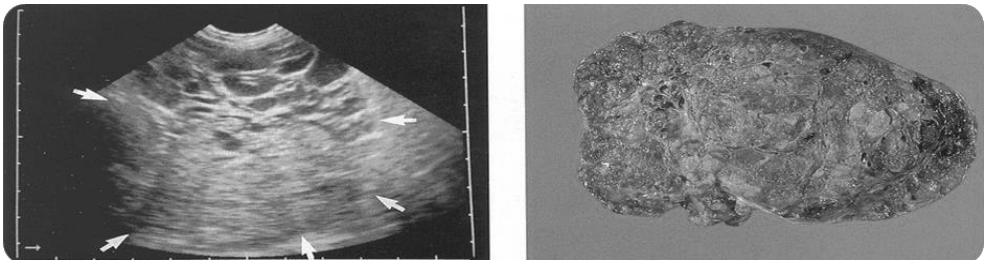
- Ovarian cysts: Persistent large follicles or luteal cysts
- Ovarian tumour



Follicular Cyst



Luteal Cyst



Ovarian Tumour

Advantages of Ultrasonography in Reproductive Practice

- Non-invasive and animal-friendly
- Early and accurate diagnosis
- Real-time functional assessment
- Improves reproductive efficiency and reduces calving interval

Limitations and Constraints

- High initial cost of equipment
- Operator-dependent interpretation
- Requires skilled personnel and training
- Limited field utility in extreme weather or remote areas

Recent Advances

- **Color Doppler Ultrasonography**: Assesses blood flow to CL, uterus, and fetus
- **3D Ultrasound**: Advanced structural evaluation
- **Automated follicular tracking**: AI-based interpretation

Recommendations for Clinical Practice and Training

- Incorporate ultrasonography into standard reproductive examination protocol

- Participate in hands-on training on USG
- Integrate with herd health and fertility monitoring programs

Conclusion

Ultrasonography has redefined veterinary reproductive examination by enhancing accuracy, safety, and efficiency. From estrus detection to early pregnancy diagnosis and genital/fetal abnormality, its clinical applications are vast and impactful. With proper training, infrastructure, and integration into field practices, reproductive ultrasonography can significantly elevate the standard of bovine fertility management. Future advancements in Doppler imaging, AI integration, and portable diagnostics will further expand its scope and accessibility.

Prosthetic management for soft tissue surgery in animals

Dr. Md. Moin Ansari
Department of Veterinary Surgery and Radiology
Bihar Veterinary College, Patna-800014

In medicine, a prosthesis (plural: prostheses; from Ancient Greek prosthesis, "addition, application, attachment, to place before" is an artificial device that replaces a missing body part, which may be lost through trauma, disease, or congenital conditions. Prosthetics are intended to restore the normal functions of the missing body part. Its application to hernia repair was preceded by appliances devised to temporarily control protrusions. Primitive man probably treated hernia by simple measures, but as civilization progressed reducible hernia was retained by bandages or girdles, and strangulated hernia was treated by rest, diet, purgation, and the application of cold water. Ancient art and writings prove that hernia was known long before the time of Christ. It was described by the ancient Egyptians and Greeks, including Hippocrates, who related that trusses had been found in Egyptian sarcophaguses. Gold wire was used as suture followed by the use of silver strands woven into filigrees for the first hernia prosthesis by ancient Greeks.

Soft tissue surgery has become the most common surgical procedure in western countries as a result of population aging as well as over-weight and obesity increasing. On this scenario, the use of meshes has become the first option in the treat-ment of hernia and urinary incontinence (UI) and widely used in pelvic organ prolapse (POP) treatment due to the high recurrence rates after primary suture techniques. For instance, it is supposed that about 11% of the women will undergo surgery to POP repair in their lifetime, and 30% of these patients will need reoperation because of prolapse recurrence within 4 years post-surgery.

It is over 130 years since Theodor Billroth, then professor of surgery at the University of Vienna, set out the challenge of soft-tissue reinforcement in a letter to one of his pupils. Since that time, both scientists and clinicians have endeavored to find a solution to a problem that remains one of the most challenging in the whole field of surgery. Soft-tissue defects of the abdominal and pelvic cavities, either primary (eg, inguinal hernia) or secondary (eg, incisional/ventral hernia), were traditionally repaired with sutures. The high rates of defect recurrence reported were unacceptable to both patients and surgeons. Early attempts at soft-tissue

reinforcement were directed at hernia repair and utilized meshes made from a variety of metals, including silver, tantalum, and stainless steel. All metallic meshes ultimately failed due to a combination of metal fatigue, erosion, bowel fistulation, and, in the era before antibiotic availability, chronic infection. It was not until the seminal work of the American surgeon Francis Usher in the 1950s and 1960s that the modern era of soft-tissue reinforcement commenced. The search for biocompatible prosthesis to correct anatomical imperfections has begun in 1894 using silver row "tissue". Metallic tissue was substituted for more flexible and shapely materials such as Fortison, polyvinyl, "nylon", silicone, Teflon, carbonate fiber, polyester, polypropylene, polytetrafluorethylene (PTFE) and polyglycolic acid (Dexon). The polypropylene prosthesis introduced in Brazil, in 1969 by Falci, are the most used in our environment avoiding excessive tension in the aponeurotic border suture line (Lichtenstein 1989). The primary aponeurotic suture done at the median line is the simplest and anatomic technique to abdominal cavity closing, although produces an elevated tension on the suture line, predisposing to dehiscence and post-surgical complications such as infection on the surgical wound, peritonitis and significant incisional hernia incidence. In the present investigation there wasn't registered dehiscence, infections, peritonitis or incisional hernia recurrence, proving the biocompatible character and the resistance of "nylon" implant used in abdominal incisional hernia reduction.

Why Prosthetics?

Animals require prosthetics for a variety of reasons, one of the most common being neonatal injuries resulting in amputation. “It's sometimes unclear why very young puppies lose portions of their limbs,” Dr. Marcellin-Little says. “It could be an overactive mother who cleans the umbilical cord and mistakenly chews the end of a newborn's foot.” Trauma is another common reason for amputation, as are tumors of the extremities, especially the toes. “Tumors of the nail bed must be excised, along with a portion of the foot,” Dr. Marcellin-Little explains. “Roughly an inch of tissue must be removed around the edge of the tumor to prevent regrowth.”

A tremendous number of factors come into play in determining whether an animal is a good candidate, including the age and size of the animal (very small and very large dogs pose greater challenges), the amount and health of the residual limb, soft tissue coverage, and skin mobility relative to underlying tissue. Other issues include possible orthopedic problems in the limb, how the limb is innervated, whether the partial limb is affecting the range of motion in adjacent joints, and gait issues.

A prosthesis should be designed and assembled according to the

person's/patient's appearance and functional needs. For instance, a person may need a transradial prosthesis, but need to choose between an aesthetic functional device, a myoelectric device, a body-powered device, or an activity specific device. The person's future goals and economical capabilities may help them choose between one or more devices.

Types:

The abdomen is a very delicate part of the body of animals. It is subjected to trauma and clinical disorders. Hernias are quite common in both young and mature animals. In massive abdominal wall defects, the use of graft becomes mandatory to achieve desirable results. Different techniques have been performed to overcome this challenge.

Craniofacial prostheses include intra-oral and extra-oral prostheses. Extra-oral prostheses are further divided into hemifacial, auricular (ear), nasal, orbital and ocular. Intra-oral prostheses include dental prostheses such as dentures, obturators, and dental implants. Prostheses of the neck include larynx substitutes, trachea and upper esophageal replacements. Somato prostheses of the torso include breast prostheses which may be either single or bilateral, full breast devices or nipple prostheses. Penile prostheses are used to treat erectile dysfunction. Limb prostheses include both upper- and lower-extremity prostheses.

Many abdominal wall defects and hernias can be repaired by a primary closure while massive defects, including irreducible hernia, need special attention, since they cannot be treated by simple methods of reduction. This type of hernia requires surgical procedures to rectify the defect by the use of graft. The concept of tension-free herniorrhaphy is a potential resolution of the controversies that have surrounded the subject of hernia surgery for more than a century. Certain hernial cases involve massive loss of abdominal muscles which cannot be repaired by simple suturing of opposing muscles; thus, grafting becomes the only option for their repair. The current standard of practice is to repair most defects using permanent synthetic mesh material. The mesh is known to augment the strength of the weakened abdominal wall fascia and to enable the hernia repair under a tension-free condition. However, this surgical procedure could be associated with a risk of infection, fistula formation, and possibility of presence of chronic abdominal wall pain. In avoidance of these postoperative injuries, surgeons are directing their efforts towards the use of xenogenic and allogenic materials for the repair of abdominal wall defects. The use of biomaterial for the repair of abdominal wall defects has gained an increasing recognition in achieving a tension-free repair, resulting in a significant reduction of

postoperative pain, shortening the recovery period, and the frequency of recurrence.

Prosthetic Materials in Repair of Abdominal Defects

Although several classification systems based on an array of mesh characteristics exist, there is no universally agreed standardized system. The easiest approach is a dichotomous division into synthetic (derived from manufactured chemicals) or biologic (either allograft or xenograft) meshes. Synthetic meshes have been used in soft-tissue reinforcement for over 50 years, in a wide array of clinical applications across a number of surgical specialties, from hernias of the abdominal wall to pelvic organ prolapse surgery. In many instances, such as inguinal hernia repair, their use has become the gold standard of care. They are not, however, without their adverse effects, such as chronic pain, foreign body sensation, and chronic infection. It is the poor outcome in terms of complications associated with the use of synthetic meshes in clean-contaminated or contaminated fields that has elicited caution about their use in such situations. Biologic prostheses derived from allo- or xenogeneic tissues have been proposed as a safer alternative to synthetics.

Natural Prosthetic Materials (Biologic prostheses /Bioprosthetics)

Many clinical complications could follow the abdominal wall repair by synthetic materials including wound infection, bowel fistula, erosion into abdominal viscera, increased recurrence rate, repair failure, and mesh extrusion. In addition, the high cost associated with synthetic material implants initiated the search for safe and cheap biodegradable material that have enough strength to support the abdominal wall during the healing process, with the ability of replacement by the recipient fibrous tissue before its complete degradation. Recently new biomaterials derived from biological material of a collagen nature including cadaveric fascia lata, tunica vaginalis, bovine pericardium, and collagen based material derived from porcine small intestine submucosa had been tested for the repair of abdominal wall defect. The repair of abdominal wall defects by biological biomaterials has better advantages over the synthetic prosthetic materials, due to their minimal adhesion formation, providing better framework for fibroblast proliferation, neovascularization, and building of multidirectional fibrous structure. These results help in better suture retention, while the material is absorbed and replaced by the host tissue. Despite the acceptable results obtained by biological prostheses, several clinical complications are reported in xenograft biologic mesh implantation including evisceration, disintegration, poor mesh integration, and infection or seroma.

Biological grafts are derived from human, bovine, and porcine tissue that has been decellularized to leave a collagen matrix. This structure acts as a regenerative framework that supports remodeling and new collagen deposition. The characteristics of each material are unique and dependent on the tissue source and the specific methods used to remove the cells and sterilize the graft. The subtle biochemical alterations in the collagen structure that take place as a result of this processing influence the biocompatibility, foreign body response, and immunogenic potential of the graft. To create a durable and permanent repair, the mesh must integrate into the host tissue. This process begins with an inflammatory response, followed by cellular and vascular infiltration and finally matrix remodeling. Each of these steps is critical to the long-term success of the graft and is dependent upon the biochemical properties of the mesh. Host macrophages at the junction of the mesh control the inflammatory response. If this response is too vigorous, it can lead to excessive scaring, graft encapsulation, and degradation. The inflammatory response signals fibroblasts resulting in new collagen deposition. Angiogenesis must also occur to allow for tissue remodeling, otherwise the graft will be replaced by scar tissue. The grafts are exposed to various enzymes that degrade them over time. To result in a successful repair, they must maintain their structure long enough for them to be integrated into the host tissue. Collagenases are enzymes that are commonly found in healing wounds and are involved in the breakdown of collagen. The collagen matrix can be chemically cross-linked to resist degradation by these enzymes. Non–cross-linked mesh is typically degraded in 2 to 3 months, whereas the cross-linked material can last several years. Theoretically, this allows the mesh to maintain its structure with slower incorporation into the native tissue.

Homograft

Human acellular dermal matrix was the first biological mesh available, and gained widespread popularity early in its history. Initial reports were promising, with good tissue incorporation and low infection rates. The majority of infections were managed with local wound care, and graft removal was necessary only in 4%. However, follow-up studies showed a high incidence of laxity, eventration, and recurrent herniation.

Xenografts

Small intestinal submucosa (SIS) tissue repair products are biologic grafts created from porcine SIS. Biodesign (Cook Medical, Inc., Bloomington, IN) is available in multiple thicknesses. It has been used in contaminated fields, and seems to hold up

well when the degree of contamination is minimal. However, it does not perform as well with gross contamination or when the fascia cannot be reapproximated (i.e., when it is used as a "bridge").10

Most challenging complex hernias involve an open abdomen, contamination, and/or gross infection, conditions that make permanent prosthetic mesh inappropriate. In this setting, temporary or bioprosthetic meshes are considered. Primary closure at the time of initial operation or second look operation with a biologic prosthesis may prevent the need for highlymorbid staged repairs. Biologic grafts have reported success in ventral hernia repair in contaminated fields of at least 75%; and up to 90% in clean cases however long term follow up is limited. There was previously a short list of bioprosthetics, but as the need for such meshes has expanded and technology has progressed, the field is now rich with choices. They differ based on their source (human or animal), composition (dermal, pericardial or submucosa) and methods of processing (stripping, cross-linking). They are more durable than absorbable nonbiologic mesh, and have the potential for permanent hernia repair under the worst of circumstances. Graft options have evolved over years, and include autografts, allografts, xenografts and synthetic materials (Table-1). Surgeon preference for graft material has varied widely, and for each material its own inherent advantages and disadvantages have been described (Jankowski et al., 2004).

Table1: Biomaterials Options For Soft Tissue Repair.

Natural	Synthetic
Autografts (rectus fascia, fascia lata, vaginal wall);	Absorbable: Polyglactic acid Permanent:
Allografts (cadaveric tissues, including dura mater, dermis, fascia lata);	Polytetrafluoroethylene; Polypropylene Polyvinylidene fluoride;
Xenografts (porcine small intestinal submucosa, porcine dermis)	Silicone elastomers; Polyester

Allografts were the first biologic mesh type to be introduced in North America, initially dominating both the market and medical literature, but they were not available in the European Union due to regulatory restrictions. Consequently, xenografts were introduced because there was a more readily available source. This made xenografts cheaper to manufacture, and the subsequent lower costs and fewer regulatory restrictions meant that xenografts generally, and porcine dermis particularly, have come to dominate the market and medical literature worldwide over the last decade. Porcine dermal prostheses are manufactured by tissue harvesting followed by a variety of proprietary decellularization and delipidation

techniques. This leaves behind the three-dimensional collagen structure and constituent elastin fibers, which may then undergo further proprietary processing steps, such as supplemental cross-linking or removal of epitopes with alpha-galactosidase. Implants then undergo a terminal sterilization process. The differences between commonly available porcine dermal meshes are summarized in 2 .

Table 2. Overview of the most commonly used and available porcine dermal meshes

Porcine dermis mesh	Manufacturer	Cross-linking	Sterilization	Size/thickness
Cross-linked				
Collamend™	Bard, Covington, GA, USA	Cross-linked collagen and elastin (EDAC)	Ethylene oxide residuals	Size: 20.3 × 25.4 cm
Permacol™	Covidien, New Haven, CT, USA	Chemically cross-linked (diisocyanate)	Gamma irradiation	Size: 28 × 40 cm Thickness: 0.5, 1, and 1.5 mm
Non-cross-linked				
InteXen™	AMS, Minnetonka, MN, USA	No	Ethylene oxide	
Strattice™	LifeCell Corporation, Bridgewater, NJ, USA	No	E-beam	Size: 20 × 20 cm
XCM	Synthes, West Chester, PA, USA	No	Proprietary Optrix processing	Size: 20 × 30 cm Thickness: 1.5±0.3 mm
XenMatrix™	Bard, Covington, GA, USA	No	E-beam	Size: 19 × 35.5 cm

Biologic grafts are acellular collagen matrices implanted during hernia repair to facilitate native tissue incorporation. The main goal is to provide the extracellular components necessary to complete healing, allow for the reconstruction of new and

healthy tissue, and restore mechanical and functional integrity to the abdominal wall. Collagen cross-linking increases the strength of the biologic graft. As the density of collagen cross-linking increases there are decreases in cellular infiltration (decreased angiogenesis), increased fibroblast encapsulation and increased resistance to degradation by the body. Biologic grafts that undergo stripping or collagen cross-linking are less able to stimulate or retain cellular growth factors to promot angiogenesis. This results in less graft incorporation and a residual foreign body. Since the density of collagen cross-linking that allows sufficient angiogenesis to sustain recapitulation is unknown, the use of collagen cross-linked grafts should be considered cautiously. In Table 3, a number of most current and available types of biologic meshes are listed with their specific features.

Table 3. Pros and cons of the current types of biologic mesh.

Mesh	**Description**	**Advantages**	**Drawbacks**
Human dermis			
AlloDerm®	Aseptic proprietary process removes all cellular material, freeze-dries dermis, and forgoes terminal gas sterilization to maintain structural integrity; non-cross-linked	Long record of safety	Relatively small sizes; must be refrigerated/rehydrated and placed under tension; stretches out over time due to elastin content
FlexHD®	Aseptic processing. No refrigeration or rehydration needed; minimal elasticity	No refrigeration or rehydration needed; minimal elasticity	Insufficient data

Mesh	Description	Advantages	Drawbacks
Human dermis			
AlloMax™	Proprietary tutoplast processing removes all cells; sterilized by low-dose gamma radiation		Hydration required; Insufficient data
Porcine dermis			
Permacol™	Acellular, chemically cross-linked to resist collagenase	No refrigeration or rehydration requirement; available in large sizes	Insufficient data
CollaMend®	Lyophilized, acellular, cross-linked collagen and elastin		Requires hydration; Insufficient data
Strattice™	Acellular, Non-cross-linked	Available in large sheets	Limited long term follow up
XenMatrix®	Acellular, Non-cross-linked	Available in large sheets	Limited long term follow up
Porcine intestine			
Surgisis®	Acellular, Non-cross-linked	No refrigeration requirement; long history of safety data	Requires hydration; susceptible to collagenases
FortaGen®	Low-level cross-linking	No hydration	Unclear safety profile

Mesh	Description	Advantages	Drawbacks
Bovine			
Veritas®	Bovine pericardium, Primarily used as peri strips staple line reinforcement	-	Insufficient data
SurgiMend™	Fetal bovine dermis, Non cross-linked	Long shelf - life	Requires rehydration; Insufficient data
Tutopatch®	Bovine pericardium	Low inflammatory response	Some recalled; insufficient data

The cross-linking debate

Collagen is the predominant molecule present in porcine dermal meshes, since it is the major extracellular component of connective tissues. There are naturally occurring covalent cross-links both within and between the triple-helical polypeptide chain structures of collagen. These cross-links are formed by either an enzymatic pathway, which is catalyzed by lysyl oxidase, or by nonenzymatic processes (eg, radiation). Natural cross-links therefore exist in native collagen and function to stabilize the structure of the collagen protein, providing mechanical strength and protection from collagenase (Sims, 2000). In this respect, all porcine dermal meshes are naturally cross-linked. Some porcine dermal meshes undergo an additional chemical processing step to deliberately increase the amount of collagen cross-links, sometimes referred to as supplemental cross-linking. The role of cross-linking and the agents used have been reviewed in detail previously (Smart, 2012). The enhanced durability of cross-linked porcine dermal implants is purported to result in better clinical outcomes for hernia repair (Smart and Bloor, 2012).

Synthetic Prosthetic Materials

More than 80 types of synthetic mesh were used in repair of abdominal wall and fascia. The synthetic materials are divided into nonabsorbable and absorbable mesh. The nonabsorbable mesh includes stainless steel, tantalum, Teflon, Orlon, silicon,

monofilament or polyfilament nylon, polypropylene, polytetrafluoroethylene, polyethylene, Dacron fabric, fiberglass, polyester, and Marlex and Mersilene mesh; however, the absorbable mesh includes fewer materials, namely, polyglycolic acid, polyglactin 910, and Bulgarian antimicrobial polyamide. The most important necessary characteristic for a successful mesh repair is the strength of the tissue incorporation. However, this characteristic could lead to a tendency towards adhesion formation. For this reason, the development of the optimal material for mesh hernia repair was essentially a balancing act between the strength of tissue incorporation and adhesion formation (Khan et al.,2008). The utilization of polypropylene mesh, discovered 40 years ago, became increasingly popular, due to its documented biocompatibility. This synthetic mesh achieved a tension-free environment at its site, resulting in significant reduction of postoperative pain, shortening of the recovery period, and reduction in frequency of postoperative reoccurrence. However, the disadvantages of this mesh lie in its inelastic nature and the high cost. Alternatively, some surgeons choose to use biologic materials that meet the structural requirements and safety.

The easy handling of polypropylene mesh helped in their frequent application for repair of abdominal wall defects in horses, ponies, cattle, and dogs. The cut edges of this mesh resist fraying and tissue granulation, helping capillaries to grow through the interstices of the mesh and strengthening its incorporation. The negative side is the observation of a tendency towards an adhesion formation. The comparison of polypropylene versus polytetrafluoroethylene patches showed that the first was associated with a significantly lower incidence of recurrent herniation, rapid fibrinous fixation to the host tissue during short time, and retaining of its original square shape.

Absorbable Material

The development of absorbable mesh using Dexon or Vicryl was triggered by the complications of using permanent mesh in contaminated fields. The material is completely absorbed between 90 and 180 days and generally results in a hernia where the mesh was placed. They do not have to be removed in the setting of infection, and therefore are often used as a temporary barrier in contaminated fields. Newer biosynthetic prostheses are being developed. The BIO-A mesh [W. L. Gore & Associates, Inc., Newark, DE] is a copolymer of polyglycolic acid and trimethylene carbonate in a three-dimensional matrix. It is designed to maintain its structure long enough for tissue ingrowth, but completely degrade in approximately 6 to 7 months. It is available as a fistula plug, inguinal plug, and mesh.

Synthetic Mesh

In considering synthetic mesh, several mechanical factors must be taken into account: tensile strength, porosity, elasticity, and method of fabrication. The tensile strength of most synthetic materials generally far exceeds the physiologic demand. However, excessive strength can lead to increased inflammation and loss of elasticity. The porosity of a mesh affects its incorporation into surrounding tissues. In general, small pores generate a strong inflammatory response that can reduce tissue ingrowth. Although larger pores allow more ingrowth and may preserve elasticity, it comes at the expense of creating an adequate scaffold for fibrous tissue growth. Finally, the material can be constructed by knitting or weaving. Knitted mesh is generally more porous and flexible than woven mesh. Woven mesh, because of the increased fiber density, is generally stronger, but serves as a poor scaffold for fibrous ingrowth. Synthetic meshes can be either permanent or absorbable. Permanent materials are generally composed of polypropylene, polyester, or expanded polytetrafluoroethylene (ePTFE). Each of these materials has benefits and limitations. They are often combined with each other or additional material to create "composite" meshes designed to take advantage of their strengths while combating their deficiencies. A wide variety of these composite meshes have been approved for clinical use. Absorbable meshes generally contain Dexon or Vicryl, and are designed to be completely degraded over time.

Polypropylene

It has been extensively used in a wide variety of surgical procedures and is relatively inexpensive. Experimental studies have shown that polypropylene mesh is well incorporated into the anterior abdominal wall within 2 weeks of implantation. However, the inflammatory reaction may predispose to adhesion formation and result in contraction of the mesh and surrounding tissues. This vigorous inflammatory reaction is thought to contribute to postoperative pain and loss of elasticity. As a result, polypropylene is available in multiple thicknesses and pore sizes. The lightweight material is designed to decrease the volume of polypropylene, and hence the inflammatory reaction resulting in improved abdominal wall compliance, less contraction of the mesh, and better tissue incorporation. While the inflammatory response generated by polypropylene contributes to its durability, it also increases adhesion formation when the mesh is used adjacent to the bowel. As a result, polypropylene is rarely used alone in the peritoneal cavity. Polypropylene may be combined with either a temporary or permanent material to reduce adhesion formation or isolate it from contact with the bowel. Temporarily lining the mesh with poliglecaprone, carboxy-methylcellulose, titanium, and omega-3 fatty acid is

designed to isolate the polypropylene from the bowel during the immediate postoperative period when adhesion formation is at its peak. ePTFE (discussed later) has also been used in conjunction with polypropylene to create a permanent barrier to protect the bowel. The inflammatory response to polypropylene also causes the material to contract by 30 to 50%. In addition to causing separation with the native tissue, the contraction can lead to rolling of composite meshes, exposing the polypropylene component to the bowel surface.

Polyester: Polyester is a carbon-based polymer frequently used in fabrics. Early studies raised concerns about higher infection, small bowel obstruction, recurrence, and fistula rates compared with other synthetic materials. While subsequent data have not supported this report, the stigma has limited its popularity. Polyester may offer some advantages over polypropylene. In an animal model of ventral hernia repair, a polyester mesh coated with a collagen hydrogel matrix (Parietex) showed superior incorporation into tissue than a composite mesh of polypropylene and sodium hyaluronate/carboxymethylcellulose .

Expanded Polytetrafluoroethylene

ePTFE is a microporous woven mesh that was originally used in vascular grafts. The material used in abdominal cases generally has two sides—one side is smooth with small (3 μm) pores, the other has larger pores (> 100 μm) with ridges and groves. The material is designed to place the smooth side toward the bowel to minimize adhesions, and the rough side toward the fascia to allow for tissue ingrowth. In an animal model of ventral hernias, grafts constructed with ePTFE were compared with those of polypropylene. While the ePTFE grafts showed less evidence of adhesions, there was no ingrowth of fibrocollagenous tissue into the ePTFE graft. The polypropylene mesh was completely incorporated. In addition, hernia recurrence was 60% in the ePTFE group, compared with 0% in the polypropylene group.

Incisional hernia/abdominal wall reconstruction

Incisional hernias develop at the site of a surgical incision made to gain access to the abdominal cavity and where the abdominal wall failed to heal. Every surgical incision to the abdomen carries risk of hernia development, and estimates of incidence in the literature vary, with rates up to 30% reported. Most of these hernias enlarge over time, and the associated morbidity frequently leads to surgical correction. Recurrence rates are time dependent and increase with successive attempts at repair.

The development of prosthetic materials for the repair of abdominal wall defects has evolved and progressed during the past several years, with the ultimate goal of

discovering the "ideal prosthesis." The classic polyester, polypropylene, and expanded polytetrafluoroethylene have been replaced by materials of natural origin, mainly from animal sources. These implants, named as "biomeshes," are primarily composed of collagen, with their ability to regenerate new tissue in the human recipient, while the biomeshes are undergoing a progressive degradation.

The ideal biomaterial for abdominal wall repair should posses adequate strength and no hypersensitivity reaction, be durable and pliable, have grainy texture to grip the peritoneum and prevent slippage, resist infection, and be reactive enough to induce a rapid fibroblastic reaction and biocompatibility to facilitate tissue in growth, which may help long term maintenance of mechanical strength. In addition, such materials should have the capacity of tolerance by the living tissue, avoiding rejection, while they are absorbed naturally by the biological processes of the body, or staying intact or partially intact, as a permanent part of the surrounding tissue.

Hybrid Mesh

Because both biologic and synthetic materials come with their own unique set of advantages and disadvantages, it is possible that they could be combined in a manner that would exploit the advantages of both, while minimizing the disadvantages. Recently, a hybrid made up of lightweight macroporous polypropylene encased in 8-ply porcine SIS has been released (Fig. 1). While data supporting the use of this product are lacking, it may, in fact, be helpful in situations where the advantages of each type of mesh were desirable. Developers of this product theorize that the biologic component will shield the synthetic component from potential infection while allowing the host to invade and replace the SIS with native tissue over time. Once the biologic component is replaced, the synthetic would be incorporated into the surrounding tissue. This could potentially allow for placement against the viscera with diminished risk of fistulization, or it may allow the use of the product as a bridge in a contaminated environment without the associated high risk of incisional hernia.

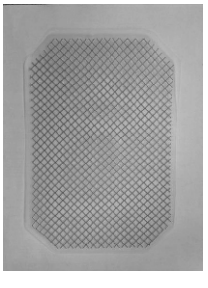


Fig. 1: Image of Zenapro (Cook Medical, Inc., Bloomington, IN), a hybrid made up of porcine small intestinal submucosa encasing a lightweight macroporous polypropylene mesh.

Techniques of Implantations

The "inlay" technique is preferred in the repair of large ventral incisional hernia, in which the mesh is sewn to the margins of the defect by simple continuous suture, interrupted only at the corners. This is described as the simplest form of repair, but it suffered from high relapse rates, since no broad mesh contact between the fascia and the prosthetic material is established. Although the inlay technique is the simplest form of repair, it has a disadvantage of lacking fixation of the implant by intra-abdominal pressure, due to minimal surface area of contact between the implant and the adjacent tissue, leading to higher frequency of relapse. The "onlay" technique of implantation has the advantages of easiness in implanting the mesh, the easiness in removal of infected stitches, and the decreased strain on the suture line due to the spread of the tension across the mesh. However, it has minor ability to relieve tension and may cause local discomfort and erosions of mesh through the subcutaneous tissue and skin. The "onlay" hernia repair has several disadvantages including tenderness of the abdominal wall, seroma formation, and highest rate of surgical site infection as well as mesh displacement from the intra-abdominal pressure. The "onlay" technique of implantation has the advantages of easiness in implanting the mesh, the easiness in removal of infected stitches, and the decreased strain on the suture line due to the spread of the tension across the mesh. However, it has minor ability to relieve tension and may cause local discomfort and erosions of mesh through the subcutaneous tissue and skin. The "onlay" hernia repair has several disadvantages including tenderness of the abdominal wall, seroma formation, and highest rate of surgical site infection as well as mesh displacement from the intra-abdominal pressure. The "underlay" retromuscular position has the advantage of excellent incorporation into the abdominal wall with sufficient protection of the viscera, although an extensive tissue dissection is required. The "underlay" technique was considered the best method because of its relatively low hernia recurrence rates. Intraperitoneal placement of polytetrafluoroethylene mesh has several advantages over other techniques, including minimal dissection, providing better fixation and possibly a decreased risk of infection. The disadvantage of intraperitoneal placement of mesh grafts is the contact of the prosthesis with viscera, which could lead to inflammatory response, resulting in intra-abdominal adhesion, for which omental interpositioning as a physical barrier is recommended.

TISSUE ENGINEERED PROTHESES (TEP)

Recent advances in cell-based technology using regenerative medicine techniques suggest that this approach holds enormous potential to improve human conditions by

encompassing alteration of the current biological state of a targeted tissue, augmentation of depleted function, or absolute functional tissue replacement. To that end, numerous cell-based investigations have been performed to address urinary incontinence. Cells derived from various sources have been used for urinary incontinence, including chondrocytes, smooth muscle cells, muscle precursor cells, adipose-derived stem cells, and bone marrow stromal cells providing coaptation of the bladder neck by augmenting tissue mass or restoring sphincter function.

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DIRECTORATE OF EXTENSION EDUCATION, BASU, PA


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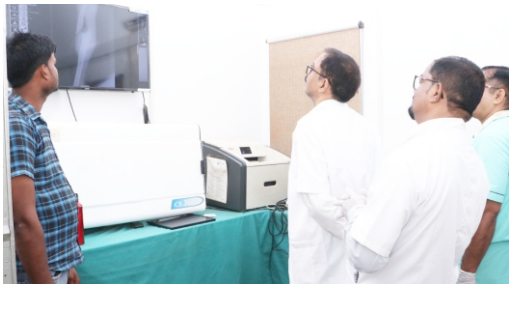

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