Manual of Small and Large Animal Anaesthesia

DEPARTMENT OF SURGERY
MADRAS VETERINARY COLLEGE
CHENNAI - 600 007.
Manual of

LARGE AND SMALL ANIMAL ANAESTHESIA

Editors

Dr. W.P. ARCHIBALD DAVID, M.V.Sc., Ph.D.,
Dr. B. JUSTIN WILLIAM, B.Sc., M.V.Sc., Ph.D.,
Dr. Capt. G. DHANAN JAYA RAO, M.V.Sc., Ph.D.,

DEPARTMENT OF SURGERY
MADRAS VETERINARY COLLEGE
TAMILNADU VETERINARY AND ANIMAL SCIENCES UNIVERSITY
CHENNAI - 600 007.

1997
FOREWORD

I am extremely happy to note that a manual has been compiled by the faculty of Surgery on Anaesthesia for the benefit of the students and field Veterinary Officers.

The science of Anaesthesia, has made rapid strides recently especially in large animal anaesthesia to the ultimate benefit for the livestock farmers.

I am happy to learn that the manual has been prepared in such a simple and concise way which is easy to understand and to grasp the information with ease.

I congratulate the authors of this manual for the efforts taken in bringing out this "Manual of Large and Small Animal Anaesthesia". I am sure the students and clinicians will benefit from this manual.

(Dr. S. Shanmugasundaram)  
VICE-CHANCELLOR
PREFACE

The objective of compiling this manual is basically to benefit the students and Veterinary officers in the field as the cost of purchasing a text book is the main limiting factor as well as the limited time available for practicing veterinarians to go through voluminous texts.

The contributors of this manual are experienced teachers and practitioners well versed with the subject and were able to write the text in such a manner to make it brief, and informative with practice oriented practical problems in mind.

The chapters have been divided under different headings so that the reader can turn to the required page easily for reference.

As it is known to all, anaesthesia has developed over the recent years to such an extent that safe anaesthetic regimen are available for practice with different combinations and wide safety margin and monitoring of the patients during anaesthesia is also possible with minimum equipments.

The readers should understand our limitations in covering the different topics as it is mainly a ready reckoner in practice point of view and as a reference for the students.

We thankfully acknowledge the efforts take by our contributing authors in helping us to bring out this manual.

W.P.ARCHIBALD DAVID
B.JUSTIN WILLIAM
G.DHANANJAYA RAO
CONTRIBUTORS

Dr. W. P. ARCHIBALD DAVID M. V. Sc., Ph. D.
Professor and Head
Department of Surgery

Dr. B. RAMESH KUMAR M. V. Sc., Ph. D.
Associate Professor
Department of Clinics

Dr. T. N. GANESH M. V. Sc., Ph. D.
Associate Professor
Department of Clinics

Dr. C. RADHA KRISHNAN M. V. Sc., Ph. D.
Assistant Professor
Department of Clinics

Dr. B. JUSTIN WILLAM B. Sc., M. V. Sc., Ph. D.
Assistant Professor
Department of Surgery

Dr. Capt. G. DHANAN JAYA RAO M. V. Sc., Ph. D.
Assistant Professor
Directorate of Clinics

Dr. R. JAYAPRAKASH M. V. Sc., Ph. D.
Assistant Professor
Department of Surgery

Dr. K. AMEERJAN M. V. Sc., Ph. D.
Professor
Department of Clinics

Dr. R. SURESH KUMAR M. V. Sc., Ph. D.
Associate Professor
Department of Surgery

Dr. C. RAMANI M. V. Sc.,
Assistant Professor
Department of Surgery

Dr. S. THILAGAR M. V. Sc., Ph. D.
Professor and Head
Peripheral Veterinary Hospital
CAHS, MMC

Dr. R. SESHACHALAM M. V. Sc.,
Assistant Professor
Directorate of Clinics
# INDEX

<table>
<thead>
<tr>
<th>CHAPTER</th>
<th>Title</th>
<th>Author(s)</th>
<th>Page No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>History of Veterinary anaesthesia</td>
<td>W.P. Archibald David</td>
<td>1</td>
</tr>
<tr>
<td>2.</td>
<td>Signs and Stages of Anaesthesia</td>
<td>W.P. Archibald David</td>
<td>7</td>
</tr>
<tr>
<td>3.</td>
<td>Premedicants</td>
<td>B. Ramesh Kumar</td>
<td>9</td>
</tr>
<tr>
<td>4.</td>
<td>Injectable Anaesthetics</td>
<td>T.N. Ganesh</td>
<td>15</td>
</tr>
<tr>
<td>5.</td>
<td>Inhalation Anaesthetics</td>
<td>W.P. Archibald David</td>
<td>20</td>
</tr>
<tr>
<td>6.</td>
<td>Muscle Relaxants</td>
<td>C. Radha Krishnan</td>
<td>25</td>
</tr>
<tr>
<td>7.</td>
<td>General anaesthesia in Ruminants</td>
<td>B. Justin William and G.D.J. Rao</td>
<td>29</td>
</tr>
<tr>
<td>9.</td>
<td>General Anaesthesia in Pigs</td>
<td>B. Justin William and R. Seshachalam</td>
<td>46</td>
</tr>
<tr>
<td>10.</td>
<td>General Anaesthesia in Dogs</td>
<td>R. Jayaparakash</td>
<td>49</td>
</tr>
<tr>
<td>CHAPTER</td>
<td>Title</td>
<td>Authors</td>
<td>Page No.</td>
</tr>
<tr>
<td>---------</td>
<td>------------------------------------------------------------</td>
<td>--------------------------------------------------------------</td>
<td>----------</td>
</tr>
<tr>
<td>11</td>
<td>General Anaesthesia in wild animals</td>
<td>G.D.J.Rao and B.Justin William</td>
<td>54</td>
</tr>
<tr>
<td>12</td>
<td>General Anaesthesia in Birds</td>
<td>G.D.J.Rao and B.Justin William</td>
<td>57</td>
</tr>
<tr>
<td>13</td>
<td>Nerve Block Techniques in large and small animals</td>
<td>K.Ameerjan</td>
<td>60</td>
</tr>
<tr>
<td>14</td>
<td>Electronarcosis, Hypothermia and Acupuncture</td>
<td>R.Suresh Kumar and R.Jayaprakash</td>
<td>67</td>
</tr>
<tr>
<td>15</td>
<td>Monitoring of Anaesthetized patients</td>
<td>W.P.Archibald David and C.Ramani</td>
<td>72</td>
</tr>
<tr>
<td>16</td>
<td>Ventilation in large and small animals</td>
<td>S.Thilagar</td>
<td>83</td>
</tr>
<tr>
<td>17</td>
<td>Anaesthetic Emergencies and Management</td>
<td>B.Justin William and G.D.J.Rao</td>
<td>90</td>
</tr>
</tbody>
</table>
1. HISTORY OF VETERINARY ANAESTHESIA

Anaesthesia is one of the miracles of medicines without which modern surgical techniques would have been impossible. Primitive anaesthesia - prior to 1842 an operative procedure was a struggle for the surgeon and an ordeal for the patient. The most important skill attributed then was not the surgeon's skill but his speed. Earliest recorded attempts to produce anaesthesia were mostly on humans.

The Egyptians employed various undetermined narcotics. The Chinese made use of Cannabis indica and the Greek physicians used various Belladonna alkaloids prior to the operations. The Syrians used strangulation as one of the method of pain relief for circumcision of their children. The asphyxiation produced unconsciousness and obviously relieved the pain for a moment allowing the surgeon to proceed with his operation. Another method they employed was that of cerebral concussion. A wooden bowl was placed over the head of the patient and was struck with a wooden hammer until the patient became unconscious. In the 19th century various alcoholic beverages were used by the surgeons on their patients to obtain relief from pain.

The first report on animal anaesthesia was in 1824 when Henry Hill Hickman successfully anaesthetized animals with carbondioxide. Later in 1853 Jackson employed ether extensively in animals. The first intravenous anaesthetic using chloral hydrate was published by Ore in 1875. After the discovery of barbiturates in 1920 use of thiopentone as an intravenous anaesthetic in small animals received a boost. Though local anaesthesia was introduced in 1892 it became popular only after 1940 when Farquharson and Formaton developed regional anaesthetic techniques in cattle.

Anaesthetics have been used in Veterinary Surgery for nearly over a century. Great strides have been made on new drugs, anaesthetic machinery; patient monitoring and equipments for anaesthetic administration with emerging rapidity.

Satisfactory anaesthesia is essential for performing painful surgeries on animals. Apart from the humanitarian point of view it induces good muscular relaxation, less haemorrhage and aids in technical efficiency.

Anesthesiology includes (1) detailed study of the clinical cases. (2) Regional techniques. (3) Pharmacological effects of the various preanesthetic and anaesthetics that are used (4) Complications that may arise during anaesthetic and preanaesthetic period. (5) Management of special surgical problems and (6) ancillary services like intravenous therapy etc.
The term anaesthetic is derived from the Greek word "anaesthesia" meaning insensibility or not feeling. Several terms are used in describing anaesthesia.

**DEFINITIONS**

1. **Analgesia** - Relief from pain without loss of consciousness.
2. **Tranquilization** - State of behavioural change in the patient who is relaxed and unconcerned by his surroundings. The patient is indifferent to minor pain.
3. **Sedation** - Is a mild degree of central depression in which the patient is awake but calm and free from nervousness.
4. **Narcosis** - Is a drug produced state of deep sleep accompanied by analgesia.
5. **Dissociative anaesthetics** - Are those that induce anaesthetic by interrupting flow of information from the unconscious to the conscious parts of the brain instead of depressing all brain centers.
6. **Local anaesthesia** - Loss of sensation in a limited body area.
7. **Regional anaesthesia** - Insensibility in a larger though limited body area.
8. **Basal anaesthesia** - Is a light level of general anaesthesia, usually produced by preanaesthetic agents. It serves as a basic for deeper anaesthesia on administration of other agents.
9. **Surgical anaesthesia** - Is unconsciousness accompanied by muscular relaxation to such a degree that surgery can be performed painlessly without struggling on the part of the patient.
10. **Balanced anaesthesia** - A synergistic combination of premedication general anaesthesia and local anaesthesia which provides optimal operating conditions for the
12. Hypnosis

Is a condition of artificially induced sleep or a trans resembling sleep resulting from moderate depression of the C.N.S.

13. General anaesthesia

It is complete unconsciousness produced by controlled reversible intoxication of the central nervous system in which there is lowered sensitive to environmental stimuli.

13. Neuroleptanalgesia

Is a state of central nervous system depression and analgesia produced without the use of barbiturates or volatile agents. The combination produced sufficient analgesia and sedation to allow surgery but still permits an auditory response.

INDICATIONS FOR THE ADMINISTRATION OF ANAESTHETICS

1. Restraint - for splinting, wound dressing, Grooming fractious animals radiotherapy and to prevent wound irritation.

2. Examination - Clinical examination of the various systems - Endoscopic examinations and Radiography.


4. Surgery of all kinds.

5. Control of convulsive seizures - in poisoning and encephalitis.

6. Euthanasia

Generally achieved by an overdose of the anaesthetic.
TYPES OF ANAESTHESIA

1. Local anaesthesia
   - by surface application - subcutaneous injections and field anaesthesia by blocking an area of skin by linear infiltration.

2. Regional anaesthesia
   - by perineural injections - spinal anaesthesia consisting of (1) epidural injection (2) Subarachnoid injection.

3. Narcosis
   - (1) In combination with local or regional anaesthesia.
   - (2) As an adjunct to general anaesthesia

4. General anaesthesia
   - By using volatile and non volatile general anaesthetic agents.

Routes for the administration of anaesthetic agents

1. Inhalation
2. Intravenous
3. Intraperitoneal
4. Subcutaneous
5. Intramuscular
6. Intrathoracic
7. Oral
8. Epidural
9. Spinal
10. Rectal.

Techniques followed for achieving anaesthesia

1. Topical application
2. Infiltration
3. Field block
4. Regional nerve blocks
5. Inhalation
6. Electronarcosis
7. Hypnosis
8. Hypothermia.

Factors to be considered in the selection of anaesthetic techniques

1. Species, breed, and age.
2. Physical status of the patient.
3. The time required for the surgical procedure, its type, severity and the surgeons skill.
4. Familiarity with the proposed anaesthetic technique.
5. Equipment and personal available.
Factors altering anaesthesia

1. Activity of the animal
2. Preanaesthetic indication,
3. Fear and excitement of the animals
4. Concurrent disease
5. Physical condition
6. Age
7. Sex
8. Relative size
9. Concentration and rate of injection of the anaesthetic agent.
10. Cardiac and Respiratory function.
11. Recent feeding.
12. Concurrent disease
13. Tolerance

Selection of an ideal anaesthetic agent

An ideal anaesthetic agent is one which

1. Permits rapid induction, quick alteration in the depth of anaesthesia and rapid recovery.
2. Does not depend on detoxifying mechanisms within the body for its destruction and elimination.
3. Does not depress respiratory and cardiac centres.
4. Is not irritant to any tissue.
5. Is inexpensive, stable, non-inflammable and non-explosive.
6. Requires no special equipment, for administration.

Evaluation of the patient’s condition, provides valuable information in the proper selection of the Anaesthetic agent to be used

Physical examinations

1. Inspection of the skin and hair coat
2. Examination of the conjunctiva, mouth, throat and other body orifices.
3. Palpation of the superficial lymph nodes
4. Palpation of the abdominal viscera
5. Auscultation of the heart and lungs
6. Determination of the body temperature.
Laboratory examination

1. Red, White, and differential blood counts,
2. Haemoglobin and/or hematocrit determination.
3. Urinalysis
4. Faecal examination,
5. Determination of blood urea nitrogen
6. Clotting time
7. Examination for filaria
8. X-ray or fluoroscopic examination.

Preparation of the patient

It is always better to have the patient off feed for 12 hours, prior to General anaesthesia. Dehydrated animals should be treated with fluids and vitamins before surgery. Anaesthesia as determined clinically and with haematocrit and haemoglobin determination should be corrected by the administration of whole blood. The patient should be placed on the operation table in a physiological position.

Prophylactic administration of antibiotic is done if contamination of the operative site is anticipated. An enema is given well before the operation to prevent contamination of the operation site with faeces. Oral antibiotics to be given to sterilize the bowel in elective surgery of the Gastrointestinal tract. Corticosteroids are indicated in aged or debilitated patients and those undergoing extensive surgery.

In toxaemic subject the detoxicating mechanisms of the liver should be reinforced by administering carbohydrates particularly glucose. In an emergency glucose saline can be administered intravenously before surgery.
2. SIGNS AND STAGES OF ANAESTHESIA

The transition from consciousness to complete surgical anaesthesia is divided into four stages.

Stage I: Induction stage and Stage of voluntary excitement

In this stage the animal is conscious and may make forcible efforts to avoid being anaesthetized. Breathing is entirely voluntary but in some animals breath-holding may occur. Fear and excitement may cause an increase in the respiratory and pulse rates. Pupils are dilated. Some animals may void urine and feces.

Stage II: Stage of involuntary excitement

The animal loses consciousness on entering this stage of anaesthesia. Reflex response to stimuli is exaggerated and limb movements may become violent requiring restraint. Dogs whimper and horses neigh. Some animals pass quietly through this stage. Respiration is irregular and breath-holding occurs because of struggling. Pharyngeal reflexes are present and progressively gets depressed and disappear as the animal enters the third stage.

Stage III: Stage of surgical anaesthesia

This stage is divided into three planes.

First plane (light) anaesthesia

This plane can be identified by the onset of regular automatic breathing and cessation of all limb movements. Eyeballs move from side to side and as the anaesthesia deepens. The movements become sluggish until they are fixed. The palpebral conjunctival and corneal reflexes disappear as anaesthesia deepens. In the dog and cat pedal reflexes are present.

Second plane (medium) anaesthesia

There is little change in the character of respiration. The laryngeal reflex persists. In horses, cattle, sheep, goat and pigs the eyeball is fixed and central but in cats and dogs the eyeball rotates downwards. Muscular relaxation becomes progressively more pronounced and in dogs and cats the pedal reflexes are sluggish.
Third plane (deep) anaesthesia

In this stage automatic breathing is still present but the respiratory rate increases while the depth of respiration decreases. The muscles are fully relaxed. In the dog and cat the eye ball become centres as the tone of eye muscle is lost. There is total absence of pedal reflexes. This plane provides optimum conditions for performing surgery.

Stage IV: Overdosage

In this stage paralysis of the thoracic muscles are complete and only diaphragmatic activity remains. Movements of the diaphragm are jerky and respiration appears gasping in nature. Pulse is rapid and pupils dilate. The eyeball becomes dry due to cessation of lacrimal secretion. If these signs are disregarded the animals condition deteriorates. The gasping respiration becomes loss in amplitude and finally stops. Cyanosis appears which is an indication of heart failure.
3. PREMEDICANTS

Preanaesthetic medication helps both anaesthetist and animal to make the induction and maintenance of anaesthesia easier for the anaesthetist. It renders the experience safer and more comfortable for the patient.

AIMS OF PREMEDICATION

1. Relieves anxiety thus overcoming the fear and resistance to anaesthesia.
2. To contract unwanted side-effects of agents used in anaesthesia.
3. To reduce the dose of anaesthetic.
4. To provide extra analgesia.

AGENTS USED AS PREMEDICANTS

1. Anticholinergic agents

These agents are used for the following effects.

a. To reduce salivation and bronchial secretions.

b. To block the effects of impulses in the vagus nerves.

c. To block certain effects produced by the drugs which stimulates the parasympathetic system.

a. Atropine

Prepared from the plant Atropa belladonna (deadly night shade). The active principle is the alkaloid atropine it acts on cerebral and medullary cells initially stimulating them then depressing. It acts on heart rate, Blood pressure increasing them. The broncial muscles are relaxed and its secretion are reduced. Dilation pupil (Mydriasis) is produced gastro intestinal tract muscle tone is reduced.

Dose rate Dogs 0.02 - 0.05 mg/Kg, cats 0.1 mg/kg and Pigs 0.3 - 1.8 mg/Kg.

b. Glycopyrrolate

It is a quaternary ammonium compound having anticholinergic effect on salivary and sweat glands. It is 5 times potent than Atropine and has a prolonged antisyilagogue effect. Dose rate 0.01-0.02 mg/kg. It is a drug of choice in horses and cats.
c. Hyoscine

It is an alkaloid prepared from the plant hyoscyamus niger. It is a more potent antisilagogue, less vagolytic. But the central nervous system effects are greater. It is contraindicated in horses due to the production of excitement caused by visual impairment.

II. Sedatives and Tranquilizers

These agents are used to control an animal to undergo surgery.

a. Phenothiazine Derivatives

This group of drugs are called antipsychotic (neuroleptic) agents since they alter the mood and calm the animals. They block α adrenoreceptors leading to hypotension, relax the cardiac sphincter of the esophagus leading to chances of regurgitation. The body temperature is reduced by vasodilation leading to heat loss.

1. Acepromazine: It is a 2-acetyl derivative of promazine. It is a popular sedative and premedicant. It is available as 2-10% solution. It induces sedation in 5-20 mins which reach maximum level by 30-45 mins and the duration lasts for 4-6 hours. Signs of excitement reactions are rare in animals after sedation. However, fall in blood pressure is noticed after administration of the drug. Hence it should be avoided in shock and hypovolemic conditions. Protrusion of penis after sedation is a common sign which may get injured due to flaccid nature. Hence it should be protected during sedations. This drug is very useful as an antiemetic against motion sickness in cats and dogs. Dose rate for sedation 0.025 - 0.1 mg/kg through IM route. Intravenous administration should be avoided.

2. Propionyl Promazine: Commonly used for large and small animal patients. The effects are similar to acepromazine. Dose rate: horses 0.15 - 0.25 mg/kg, Dogs 0.2-0.3 mg/kg.

3. Chlorpromazine HCl (Largactil): The action is similar to acepromazine but less potent. Dose 1 mg/kg and the sedative effect is longer in duration. It is an unreliable drug in horses due to panic caused by muscle weakness. It is indicated for the following conditions (1) for restraint during induction of anesthesia (2) to reduce the volume of general anesthesia (3) to prevent vomiting (4) to improve muscle relaxation and (5) to eliminate struggling and crying during recovery period.
4. **Promazine HCl (sparine)**: The action is similar to chlorpromazine but produces less hypnotics and fewer side effects. It is preferred in horses at the dose rate of 1 mg/Kg body wt.

5. **Triflupromazine HCl (Siquil)**: It is 3-5 times potent tranquilizer than chlorpromazine and 10 times potent antiemetic. It effectively reduces the dose of barbiturate to \( \frac{1}{2} \) to \( \frac{1}{3} \), dose. It is given at the dose rate of 1-2 mg/Kg. It produces depression in blood pressure and respiration and elevation of heart rate in goats hence contraindicated.

6. **Methotrimeprazine**: It is a potent analgesic. 0.7 times potent than morphine. In combination with etorphine (Immobilan SA) it is used as neuroleptanalgesia mixture in small animals.

7. **Promethazine**: It is the first phenothiazine derivative used in veterinary anaesthesia. It is a potent antihistamine and useful along with anaesthetic drugs which cause histamine release.

b. **Butrophenones**

They are major tranquilizers used in veterinary practice. They cause very unpleasant side effects like excitement, restlessness and mental agitation.

1. **Azaperone**: Useful in pigs for good sedative effect usually administered by intramuscular route at the rate of 1-2 mg/kg. The peak effect is achieved in 15-30 mts. with duration about 1-2 hours. 2-4 mg/kg dose rate serves as premedication to caesarean with local or general anaesthesia. Azaperone (0.4 mg/kg) with metomidate (2.5 mg/kg) gives complete anaesthesia for 2 hours.

2. **Droperidol**: It is a short acting tranquilizer which has a potent antiemetic property. Dose rate 0.1 - 0.4 mg/Kg in pigs. When combined with Fentanyl (Innovar vet) the combination gives good anaesthesia.

c. **Benzodiazepines**

These agents are used as premedicants for induction of general anaesthesia. These drugs produce antianxiety effect, sedation and hypnosis, anticonvulsive effects and muscle relaxation.

1. **Diazepam (Calm pose, Valium)**: It is a preanaesthetic agent having calming effect, muscle relaxant and anticonvulsive effects useful for relief of skeletal muscle spasms against convulsive seizures. It can be given at the dose of 0.05 - 0.4
mg/kg intravenously. Doses exceeding 0.2 mg/kg cause recumbency. Post operative convulsions may be controlled with the dose of 5 mg by slow intravenous route. It can be used as a premedicant to ketamine anaesthesia for horses and cats to abolish convulsions.

2. Midazolam: Used for induction of anaesthesia by intravenous route. Useful in small animal patients with Ketamine (in cats). Midazolam (0.25 mg/kg) and metaclopramide (3.3 mg/kg) gives good sedation in pigs. Midazolam (0.3 mg/kg) and droperidol (0.5 mg/kg) also produces excellent sedation.

3. Climazolam: It is a rapid acting tranquilizer used in cattle, sheep, horses and dogs by oral route at the rate of 5 mg/kg. Climazolam (1-1.5 mg/kg) with fentanyl (5-15 μg/kg) is useful in dogs.

4. Zolazepam: It has a marked hypnotic effect and used with tiletamine (dissociative agent).

d. α-Adrenoceptor Agonists

These agents produce potent non narcotic sedative, analgesic and muscle relaxant effects. CNS depression is mediated by stimulation of α receptors. Muscle relaxation is by inhibition of intraneural transmission of impulses in the CNS.

1. Xylazine: Potent sedative, analgesic and muscle relaxant. Used as 2% solution in dogs, cattle, horses, cats, deer etc. It is good preanaesthetic agent which effectively reduce the dose of barbiturates used for general anaesthesia by 1/3 - 1/2 dose. It reduces the dose of Halothane by 40%. The onset takes place 10-15 mts after intramuscular administration 3-5 mts after intravenous route. The peak effect will be between 12 and 14 minutes the duration of sedation in various animal as follows: Sheep 23 mts, horses 50 mts, Dogs 30 mts and Cattle 30 mts. The sleep like stage will last for 1-2 hrs and analgesia will be there for 15-30 mts xylazine produces bradycardia with fall in blood pressure. It causes emesis in simple stomach animals and produces atony of G.I. tract. A combination of atropine sulphate (0.05 mg/kg), acepromazine (0.5 mg/kg) and xylazine (2.2 mg/kg) produces excellent muscle relaxation, deep sedation and moderate anagesia in dogs. Combination of ketamine-xylazine is useful in horses. Xylazine (1.1 mg/kg) and fentanyl (0.055 mg/kg) combination controls visceral pain in horses. In ruminants 1/10 -1/5 dose rate of horses produces effective sedation. Reduction in heart rate, Cardiac output and arterial blood pressure are noticed. Tympany, regurgitation and abortion in the last trimester of pregnancy also observed in ruminants.
Dose rate of Xylazine

<table>
<thead>
<tr>
<th>Species</th>
<th>I/M per Kg</th>
<th>I/V per Kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horse</td>
<td>0.5 - 1.1 mg</td>
<td>1 - 2 mg</td>
</tr>
<tr>
<td>Cattle</td>
<td>0.03 - 0.1 mg</td>
<td>0.1 - 0.2 mg</td>
</tr>
<tr>
<td>Sheep</td>
<td>0.05 - 0.1 mg</td>
<td>0.1 - 0.3 mg</td>
</tr>
<tr>
<td>Goats</td>
<td>0.01 - 0.5 mg</td>
<td>0.05 - 0.5 mg</td>
</tr>
<tr>
<td>Pig</td>
<td>-</td>
<td>2-3 mg</td>
</tr>
<tr>
<td>Dogs &amp; Cats</td>
<td>0.5 - 1 mg</td>
<td>1 - 2 mg</td>
</tr>
<tr>
<td>Birds</td>
<td>-</td>
<td>5 - 10 mg</td>
</tr>
</tbody>
</table>

α-adrenoceptor antagonists are useful against the effects of xylazine. 4 aminopyridine (0.3 mg/kg) and yohimbine (0.125 mg/kg) given intravenously in dogs and cattle antagonise the effects of xylazine. Doxapram at the rate of 2 mg/Kg by intramuscular route reverses sedation in dogs. Atipamazole at the rate of 25-50 μg/Kg by intravenous or intramuscular routes are useful. Tolozoline at the rate of 0.2 mg/kg reverses the effect.

2. Detomidine: It is a sedative, analgesic agent and effective for equine colic. It does not produce ecbolic effect on uterus hence safe in pregnant animals. Dose 10-20 μg/kg in horses, 10-30 μg/kg in cattle. It is a good premedicant to ketamine, thiopentone and propofol. Muscular twitching, sweating, hyperglycemia, reduced gut motility and diuresis are the side effects of this agent.

3. Medetomidine: It is sedative, hypnotic, analgesic and premedicant drug. It is safe against pregnancy dose. Dogs 40-80 μg/kg, Cat 80-150 μg/kg by intramuscular route. Sedation produced in 20 mts and ataxia seen. Vomiting is seen in dogs and cats. With ketamine it is useful for general anaesthesia. For sheep and cattle dose rate of 10-20 μg/kg by intravenous route gives excellent immobilisation and muscle relaxation.

4. Romifidine: It is sedative and premedicant in horses at the dose rate of 80 μg/kg by intravenous route. It produces less ataxia and longer duration of sedation.
III. ANALGESICS

Use of analgesic drugs as premedicants help in smooth pain-free recovery. Local analgesics, opioid drugs, \( \alpha \)-adrenoceptor agonists and non-steroidal anti inflammatory drugs are useful analgesic agents in veterinary practice.

**Opioid Agonists**

1. **Morphine**: It is an alkaloid found in the opium derived from the plant papaver somniferum. It is a potent analgesic, respiratory depressent, bradycardiac, hypotensive (Dogs) and hypertensive (horses). Dose 0.1 - 0.3 mg/kg and the duration lost 4 hrs - Cat 0.1 mg/kg excitement.

2. **Papaveretum**: It contains all alkaloids of opium produces less vomiting. Combination of papaveretum (20 mg) Hyoscine (0.4 mg) and acepromazine (3 mg) are useful in animals.

3. **Pethidine**: It is 1/10 potent than morphine and produces pain relief for shorter duration of 1½ to 2 hrs. Relaxes intestinal spasms hence useful against colic. Dose rate 1 mg/kg cat 10-20 mg per animal.

4. **Methadone**: Equipotent as morphine in terms of analgesia but produces less sedation in dogs. Causes ataxia in horses. Dose horse 0.1 mg/kg Dog 0.25 mg/kg.

5. **Fentanyl**: Fifty times more potent than morphine. Produces high level of analgesia by all routes of administration. Duration 15-20 mts dose 0.2 mg/kg used in the mixture of neuroleptanalgesia for dogs also used for balanced anaesthesia and post-operative analgesia.

6. **Pentazocine**: Useful for colic in horses at the rate of 0.33 mg/kg by intravenous route. Analgesia is produced at the dose rate of 1-3 mg/kg with duration of 1-3 hours. Dysphoria is caused in animals.

Alfentanil, Etorphine, Buprenorphine and Butyrophenol are also used as analgesic agents in veterinary practice.
4. INJECTABLE ANESTHETICS

The first monograph on intravenous anaesthesia using chloral hydrate was published by Ore in 1875. Three years later Humbert described its use in the horse. Discovery of barbiturates in late 1920's revolutionized the art of anaesthesia. Thiopental sodium, the most popular and successful injectable anaesthetic was introduced in 1934. Eventhough application of inhalation anaesthesia was rapidly expanding during 1970's resurgence of injectable anaesthesia occurred in mid 1980's.

Characters of ideal injectable anaesthetic

The ideal characters of injectable anaethetics are grouped under three headings as follows:

1. Physiochemical and pharmacokinetic
   Water soluble
   Long shelf life
   Stable when exposed to light
   Small volume for induction.

2. Pharmacodynamics
   Minimal individual variation
   Safe therapeutic ratio
   Onset, one vein to brain circulation time
   Short duration
   Inactivated to nontoxic metabolites
   Smooth emergence
   Absence of anaphylaxis
   Absence of histamine release

3. Side effects
   Absence of local toxicity
   No effect on vital organs function

Classification

The injectable anesthetics are broadly classified into barbiturates, non barbiturates and dissociative agents.

The drugs available under barbiturates are as follows:
Oxybarbiturates

i. Phenobarbital Sodium
ii. Pentobarbital Sodium
iii. Methohexital Sodium

Thiobarbiturates

i. Thiopental Sodium
ii. Thiamylal Sodium

The drugs available under non barbiturates are as follows:

i. Althesan (Saffan)
ii. Chloral hydrate
iii. Chloralose
iv. Urethan
v. Magnesium sulphate
vi. Metomidate
vii. Etomidate
viii. Propofol
ix. Propanidid
x. Tricaine Methanesulfonate

The drugs available under dissociative agents are:

i. Phencyclidine
ii. Tiletamine
iii. Ketamine

Only the commonly used injectable anaesthetic drugs are described

1. Thiopental Sodium

Thiopental sodium was the first thiobarbiturates to gain popularity as an anaesthetic agent for animals. It is a thioanalogue of pentobarbital sodium. Injectable drug is prepared by mixing with sterile water or saline as 1.25%, 2.5%, 5.0%, 6.4% or 10% solution. It should be stored in refrigerator at 5-6°C to retard deterioration. Storage makes the solution turbid and to precipitate. There will be progressive loss of activity without increase in toxicity. Since potency decreases large quantity of solution is needed.
Thiopental causes marked depression of respiratory center and the rate and amplitude of respiration are affected. The drug is absorbed by fat, detoxicated in liver and eliminated through kidneys.

In small animals thiopental sodium is used for induction or short anaesthesia. The percentage of the solution prepared depends on the size of the animal. For rapid anesthesia of short duration the dose is 6-8 mg/kg. For surgical anesthesia of 10-20 mins duration the dose required is 20-30 mg/kg. About 1/3rd of the solution is injected rapidly (within 15 sec’s) and the remaining slowly. It takes 1-1½ hours to recovery and to stand by the animal. The dose required following preanesthetic sedation is 10-20 mg/kg. To prolong the anesthesia incremental dose of the anaesthetic is used.

In horses, thiopental is administered for rapid induction of anesthesia. It is injected intravenously at the rate of 6-15 mg/kg after preanesthetic sedation with tranquilizer (promazine; acepromazine). For longer duration of anesthesia large dose is required. Hence, half of the dose is administered rapidly and the remainder slowly after the horse is recumbent. By combining with glyceryl guaiacolate anesthesia can be prolonged. Thiopental is contraindicated in new born foal because the recovery may be unduly prolonged.

In cattle small dose is used to induce anesthesia and once induced to prevent aspiration of ruminal contents endotracheal intubation is done. It is contraindicated in newborn calves. In small ruminants rapid intravenous induction is done with 8-12 mg/kg thiopental sodium. Larger doses by slow intravenous injection produces 10-20 mins of surgical anesthesia.

In swines the dose is more variable and the surgical anesthesia is induced with 5% solution at the rate of 2.5 - 5.0 mg/kg body weight. Even during light anesthesia respiratory depression with irregular breathing and apnea occurs commonly.

Barbiturates are administered by intravenous, intraperitoneal, intramuscular or subcutaneous (wild animals) or intrathoracic routes (in cats).

2. Althesin (Saffan)

It is a mixture of 2 steroids in cremophor EL. Each ml of saffan contains 9 mg of alphaxalone and 3 mg of alphadolone. Saffan introduced by Glaxo is an anaesthetic for cats but can be used for all domesticated animals except dogs. Induction is not smooth as that of thiopentone and to avoid retching and vomiting induction dose is given rapidly. During cesarean section it has very minor adverse effects on kittens when induction dose of upto 6 mg/kg are given to the mother. Kittens breathe immediately after delivery when the dose is restricted to less than 4 mg/kg. Cats recovering from anesthesia often show tremor of muscles, paddle and if
stimulated may become extremely excited or convulse. Oedema and or hyperemia of cats ear pinna and paws is common under Saffan anaesthesia.

Five important characteristics of Saffan are:

i. The high therapeutic index
ii. Lack of cumulation in the body
iii. Rapid, complete recovery of consciousness and appetite
iv. Little respiratory depression with adequate muscle relaxation
v. Lack of local irritant properties and activity when given accidentally outside a vein.

3. Chloral hydrate

It is a hypnotic and the colourless translucent crystals volatize on exposure to air and produce an aromatic penetrating odour. When given orally it irritates gastric mucosa and causes vomiting. It is given intravenously and also by intraperitoneal route. It is a good hypnotic but a poor anaesthetic. The margin of safety is such that it is not a satisfactory surgical anaesthetic and hence not used in small animals. However, it is used in large animals because it is simple to administer, produces sufficient duration of effect, inexpensive and may be combined with barbiturate. Generally 7-12% W/V aqueous solutions are used intravenously.

In horses the following dose are used.

i. 2-3 g per 45 kg as sedative
ii. 10 g per 45 kg for general anaesthesia
iii. 0.6-1.2 g per 45 kg to enhance xylazine sedation.

Chloral hydrate is primarily used to induce sedation and analgesia produced by local or regional anaesthesia. Chloralhydrate is also used to induce narcosis or anaesthesia in cattle and pigs. The dose is same as in horse It is also combined with mag.sulph or mag.sulph and pentobarbital for giving anaesthesia in horses and cattle.

4. Metomidate

It is a imidazole derivative and nonbarbiturate intravenous hypnotic introduced for pigs, used experimentally in horses and for restraint of birds. It has a strong central muscle relaxant properties without analgesic activity and so used either with fentanyl or azaperone. It has a short duration of action and the peak effect is over by 25 minutes. Although metomidate is indicated for pigs it is not widely practiced.
5. **Propofol**

Propofol is unrelated to barbiturates, enganols or steroid anaesthetic. It is slightly soluble in water and marketed as a aqueous emulsion (propofol 10 mg, soyabeen oil 100 mg, glycerol 22.5 mg, egg lecithin 12 mg per ml and sodium hydroxide to adjust pH).

In dogs and cats there is rapid onset of action with short duration of action. There is rapid and smooth emergence. Propofol is a sedative hypnotic and has only minimum analgesic action. Preanesthetic morphine or medetomidine decrease the induction dose of propofol.

**Dose of Propofol**

For induction (without premedication) 6-8 mg per kg intravenously.

For induction (sedated) 2-4 mg per kg intravenously.

The recovery in dogs is 20 mts and in cats it is 30 mts. When premedicated with 0.02 - 0.04 mg per kg of acepromazine the induction dose of propofol is decreased by 30-40%. The drug is excreted primarily by kidneys. Propofol is used for cesarean section. The cost of propofol prohibits its routine use in large animals. The disadvantages in using propofol are the high cost, lack of FDA approval and the limited shelf life (once ampoule is opened there is risk of androgenic sepsis).

6. **Ketamine**

Ketamine hydrochloride is an analogue of phencyclidine with a short duration of action. When used alone it fails to produce good skeletal muscle relaxation, can lead to stormy recovery, convulsions in dogs and occasionally in cats. To eliminate these side effects diazepam, acepromazine, xylazine, throbarturates or inhalation anesthetics are used concurrently with ketamine.

During anaesthesia mild cardiac stimulation and respiratory depression occur. The eyes usually remain open with the pupils dilated. The dose of ketamine in cats is 5-20 mg per lb intramuscularly depending on the condition and age. They become recumbent in 1-8 mts and the duration of anaesthesia is for 30-40 mts. It is also given intravenously at the rate of 2-4 mg per lb and found satisfactory in dogs and cats. Before giving ketamine premedication with 0.5 mg of promazine or 1 mg of acepromazine per lb is necessary in dogs. Intramuscular injection of 100 mg per lb is safe for several species of birds. The antidote for ketamine is physostigmine salicylate.
5. INHALATION ANAESTHETICS

Drugs and gases used as inhalation anaesthetics enter and leave primarily via the pulmonary system and provides the most controllable method of producing general anaesthesia. The effect of anaesthetics varies according to their concentration. Inhalation anaesthesia has two distinct advantages. (1) The agents are primarily exhaled through the lungs. (2) Therefore recovery from anaesthesia is not dependent solely upon redistribution within the body and detoxification mechanisms. In poor surgical risk patients it is very helpful. (3) As these agents are rapidly exhaled the anaesthetist has good control over the level of anaesthesia. The depth can be quickly altered at any time. The disadvantages that are inherent with these agents are (1) they require constant surveillance (2) Some of these agents are explosive and inflammable (3) They require costly equipment for their administration (4) some irritate body tissue (5) constant exposure to some inhalant anaesthetic mixture is hazardous to operating room personal.

Metabolism of volatile anaesthetic agents

For many years it was believed that volatile anaesthetic agents were not metabolized in the body but were eliminated by exhalation, urine, faeces and sweat. But radioactive labelled studies revealed that a small percentage is metabolized and the metabolites are eliminated in exhaled air and urine.

Inhalation anaesthetic agents

Inhalation anaesthetic agents are divided into volatile liquids and gases according to their physical state.

Volatile liquid anaesthetics

Chloroform

Chloroform is a heavy sweet swelling liquid neither inflammable nor explosive. The liquid is irritating to both skin and mucous membrane. It is a powerful anaesthetic, a concentration of 0.035% produces anaesthesia while 0.06% is fatal. Because of its toxicity as cardiovascular, hepatic and renal systems it is not used in clinical anaesthesia.

Ethyl chloride & Trichlorethylene

These two drugs were used as inhalation anaesthesia, because of their cardiotoxicity, poor muscle relaxation and sensitization to epinephrine they are not used at present.
Ether

It is a colourless highly volatile liquid with a pungent odour and irritating vapour and is heavier than air inflammable and explosive. Ether is decomposed by air light and heat and therefore should be stored in amber coloured bottles and in a cool dark place. On the central nervous system it exerts an initial effect of excitement followed by depression. The margin between the anaesthetic and toxic doses is very wide and hence is one of the safest anaesthetic. The concentration necessary for anaesthesia is 3.5 to 4.5%. because it irritates the mucous membranes of the respiratory tract breath-holding by the patient is common during induction. Ether irritates kidney tissues and reduces urine output. On the heart disturbances of rhythm and extrasystoles frequently occur. Cardiac output is increased during induction. During surgical anaesthesia there is fall in blood pressure. During anaesthesia there is haemoconcentration with an increase in red cell count and haemoglobin. With leucocytosis. The advantages of ether anaesthesia are good muscular relaxation and wide margin of safety. The disadvantages are long induction period, slow recovery. It irritates tissues and is highly explosive.

Methoxyflurane

It is a clear colourless liquid which will not explode in any concentration at room temperature. It vaporizes 10 times more than water, and maintenance of anaesthesia can be achieved with concentrations of 0.4 to 1%. It produces good analgesia and muscle relaxation. Assessing the depth of anaesthesia by observing the eyeball is difficult as the eyeball gets fixed early. Unlike ether it does not produce salivation. Respiratory rate increased initially followed by decreases in rate and minute volume. Blood pressure falls progressively. Heart rate is decreased and cardiac output is decreased. The tone and motility of the gastrointestinal tract are decreased. The blood sugar level is reduced. No effects are seen in blood cells or coagulation time. The advantages are lack of explosiveness, good muscle relaxation, freedom from side effects and toxicity and high margin of safety. The disadvantages are it crosses the placental barrier and depresses the newborn. Slow induction, respiratory acidosis, fall in blood pressure.

Enflurane

It is a clear colourless noninflammable anaesthetic agent with a mild odour. Induction and recovery from anaesthesia are rapid. It does not stimulate, salivation or bronchial secretions. Blood pressure falls during induction but later becomes normal. There is no change in cardiac rhythm. For maintenance of anaesthesia 3% concentration using a vaporizer is advisable. No changes are seen on ophthalmic, bone marrow, haematologic, clinical chemistry and urinalysis. It does not produce any renal or hepatotoxicity.
Halothane

It is a clear, colourless, volatile liquid with a non-irritating odour. Halothane is non-explosive and non-inflammable when mixed with oxygen. Vapour in concentration of 2 to 4% produces surgical anaesthesia and can be maintained with a concentration of 0.8% to 1.2% mixtures. Halothane is four times potent than Ether. Recovery is rapid, it produces fall in blood pressure nodal rhythms, ventricular tachycardia and varying degrees of arrhythmia. Amplitude and frequency of respirations are decreased. There is no change is salivary and bronchial secretions. Because of its rapid induction and recovery it is the most popular anaesthetic.

Isoflurane

Isoflurane is a volatile halogenated inhalation agent, noninflammable and non explosive. The vapour pressure is identical to that of halothane to the same vaporizer can be used. Isoflurane produces minimal changes in blood counts and biochemical values. Compared to enflurane, isoflurane causes less reduction in cardiovascular function and cardiac rhythm. If increases cerebral blood flow, intracranial pressure and enhances the action of muscle relaxants. In dogs renal blood flow, glomerular filtration and urinary flow are reduced. Is an ideal anaesthetic for most surgical procedures. The only disadvantage is its cost.

ANAESTHETIC GASES

Nitrous oxide

Nitrous oxide is a colourless gas with a faint pleasant smell. It is not inflammable or explosive but it will support combustion. The gas is compressed to the atmosphere and stored in blue coloured cylinders. It is not irritant to the respiratory mucosa. The gas is a weak anaesthetic and must be combined with ether or other intravenous anaesthetics to produce desirable anaesthetics effects. It is usually used for maintaining anaesthesia. A phenomenon called "diffusion hypoxia" sometimes occurs immediately following anaesthesia with nitrous oxide. The hypoxia produced may even cause cardiac arrest. The disadvantage of nitrous oxide are its lack of potency, its inability to produce muscle relaxation, its narrow margin of anaesthesia, cost and necessity for expensive apparatus.

Cyclopropane

Cyclopropane is a colourless gas with a characteristic odour. It is one and a half times heavier than air and liquid at 15°C under 75 lbs/sq. inch and stored in orange coloured cylinders. It is inflammable and mixtures with oxygen are explosive. It is quickly eliminated and recovery even after prolonged administration is abrupt. Anaesthesia is produced in a concentration of 15 to 20% with oxygen. The gas is non-irritating to mucous membrane. It has pronounced effect on
cardiovascular system most characteristic feature increased haemorrhage at operation site. It also depresses respiration. cardiac arrhythmias are common during anaesthesia. Because of its high cost, explosion risk and its deleterious action on vital systems it is not used commonly in veterinary anaesthesia.

The administration of inhalation agents

At normal atmospheric pressure and temperature some of the inhalation agents are liquid (eg) Ether whereas others such as nitrous oxide are in gaseous state. The methods by which the vapours of the volatile liquids and the gaseous agents are delivered to the animal can be classified as

1. the open method
2. The semi open method
3. The closed method with carbon dioxide absorption.
4. The semi closed method.

1. The open method

In this method the anaesthetic agents are dropped on to the surface of gauze or lint which is held over the animals nostrils. The gauze may be stretched over a wire frame. This method is also called as rag and bottle anaesthesia. (e.g) schimmelbusch mask, Bellamy Gardner Bottle. The mask must not fit the contour of the animals face and there should be free flow of air between the mask and face.

2. The semi open method

This method is also called as perhalation methods. All the inspired air is made to pass through the mask on which the vaporization occurs. These masks are cylinders of leather or canvas and they are applied over either the upper jaw or both. Hobdays mask COX chloroform mask, Nedler’s mask. Dragger face mask for small animals. The open and semiopen systems have many disadvantages. The anaesthetist lacks control of ventilation, there is wastage of large quantities of anaesthetics and the surrounding atmosphere becomes charged with these gases which may also lead to risk of fire or explosion if flammable anaesthetics are used.

3. The closed method with carbon dioxide absorption

When anaesthetic vapours and gases are used the exhaled air contains the gas and vapour along with carbon dioxide. In this exhaled air if carbon dioxide is removed and sufficient oxygen is added to satisfy the metabolic needs the same gas or vapour can be rebreathed continuously from the bag. This is called closed circuit administration. In anaesthesia carbon dioxide is removed
by directing the exhaled mixture over soda lime which is a mixture of 90% calcium hydroxide, 5% sodium hydroxide together with 5% silicate. It has an indicator dye which changes colour when the carbon dioxide absorbing capacity is exhausted. The main disadvantage is the resistance to respiration due to packed soda lime and so unsuitable for small puppies and cats. Conservation of heat and water vapour may give rise to heat stroke in dogs and cats. During the process of chemical action in the canister fine powder are liberated which when inhaled may produce aspiration pneumonia. There are two systems in use for closed circuit carbon dioxide absorption techniques of anaesthesia.

a) The to and fro system

A canister full of soda lime is interposed between the animal and the rebreathing bag, fresh gases being fed into the system as close to the animal as possible to effect changes in the mixture rapidly. eg. Water’s carbon dioxide absorber, Sanford’s infant size absorber, Cambridge to and fro absorber.

b) The circle system

The circle system for carbon dioxide incorporates an inspiratory and an expiratory tube with unidirectional valves to ensure a one way flow of gases, the rebreathing bag and soda lime canister are placed between these tubes. They are not suitable for animals below 15 kg body weight (eg.) Boyle circle absorber mark III, Fisher and Jennings circle absorber, Weaver circle absorber unit. The gases are delivered to the patient through a cuffed endotracheal tube.

4. The semi-closed method

The principle of semi closed method is that gases flow from the anaesthetic apparatus into a reservoir bag from where the animal inhales while part of all of the exhaled mixture passes through an expiratory valve into the atmosphere. The Magill’s attachment which incorporates a reservoir bag, wide bore corrugated tubing and a spring loaded expiratory valve is the common equipment used for the administration of anaesthetic gases by semi-closed system.
6. MUSCLE RELAXANTS

Muscle relaxants or neuromuscular blocking agents are drugs that interfere with or block neuromuscular transmission. They are neither anesthetics nor analgesics but can be used only as an adjunct to general anesthesia. They do not have any influence on CNS and cardiovascular functions and hence they provide no analgesia, sedation or hypnosis and stop ventilation. This necessitates controlled ventilation and constant patient monitoring.

Inspite of the risk involves the muscle relaxants are used.

i. To facilitate tracheal intubation
ii. To paralyse respiratory muscles so that artificial respiration can be easily controlled.
iii. To increase muscle relaxation during surgery to facilitate easy access to difficult anatomical region.
iv. To evoke muscle relaxation to facilitate orthopedic manipulation and particularly fracture reduction.
v. As a part of general anaesthesia to reduce the amount of general anesthetics used.

Methods of abolishing muscle tone

During anaesthesia abolition of muscle tone and ability to contract pulses can be brought about in three ways.

i. By the use of centrally acting drugs like ether, chloroform and barbiturates. These drugs cause depression of CNS and decreases activity of Ventral horns cell in spinal cord and muscle relaxation. A profound degree of muscle relaxation can be obtained when a potent narcotic drug is used in doses that produce generalised depression of CNS and their consequences are wide spread. For example, depression of medullary centre leads to circulatory failure during surgery. Deep narcosis may cause circulatory changes due to postural changes. After a deep narcosis there is likely to be a period of depression and immobility which can predispose to complication to pneumonia and aspiration of ingesta.

ii. The second method of producing muscle relaxation is by using drugs that have peripheral action. Muscle fibres or nerve endings are blocked when local analgesic are directly injected into a muscle mass.

Eg. Paravertebral block in cattle. Here the local analgesic effect does not have any influence on the animals temperament and this makes these drugs unsuitable. Moreover the injection of local analgesic is time consuming and there is a delay before the full degree of relaxation is obtained.
iii. The third group of drugs act in the neuromuscular junction itself and are called muscle relaxants. They have no significant action in the body other than at the neuromuscular junction and their action is instant and certain. In order to understand their action it is essential to know the sequence of action at the neuromuscular when the nerve impulses are conducted.

The terminal branches of motor axon loose their myelin sheath and embed within invagination of cell membrane of the muscle fibres. The cell membrane contain protein receptors. When the impulse arrive at the terminal nerve fibres, acetylcholine is produced which attaches themselves to the membrane receptors. This causes change in permeability of the membrane to all ions. The influence of the ion causes changes in end potential at the neuromuscular junction resulting the contraction of the muscle. The acetylcholine is hydrolysed to acetic acid and choline by the enzyme cholinesterase.

To achieve muscle relaxation the nerve impulse has to be interfered with and there are several ways for it.

i. 
   a. By interfering with the release of acetylcholine the transmission of nerve impulses could be interfered. Eg. Procaine.
   b. Deficiency of Calcium & Magnesium.

ii. By delaying the break down of acetylcholine leading to persistent presence of acetylcholine.

Eg. Neostigmine and edrophonium these drugs are anticholinesterase.

iii. By using agents that produce depolarization and continue to persist at the endplate so that the impulses could be stoped. These drugs are not hydrolysed by cholinesterase and they are termed depolarizing agents.

Eg. Decamethonium & Succinylcholine.

iv. Drugs that occupy receptors at the cell membrane thus preventing acetylcholine from being attached to the receptors. They are known as non-depolarizing agents a competitive inhibitors.

Eg. 
   a. Tubocurarine chloride
   b. Gallamine (flaxedil)
   c. Pancuronium (Pavulon)
   d. Benzaquinonium (Mytolon)
   e. Metacurine iodide (Metabise)
   f. Hexafluroneum (Mylexon)
Pattern of neuromuscular block

Upon administration of muscle relaxants the muscles of face and tail are paralysed within 30-60 seconds. This is followed by the paralysis of neck and distal limbs and after this the proximal limbs and swallowing muscles are paralysed. The muscles of abdomen and intercostal muscles get paralysed next and followed finally by diaphragm. The sequence of recovery is almost the reversal of that of paralysis.

Clinical difference between depolarizing and non depolarizing agents

Depolarizing agents cause transient muscle fasciculation due to synchronous depolarization. This is followed by paralysis due to prolonged depolarization of motor end plate. The paralysis is not reversed by anticholinesterase agents and is terminated by metabolism by pseudo cholinesterase.

Non depolarizing agents do not cause muscle fasciculation and their effects can be reversed by anticholinesterase agents.

Depolarizing blocking agents

i. Succinyl choline chloride

Dose (Mg/Kg, IV), Dog 0.2, Cat 1.0, Pig 1.0, Horse 0.04.

Side Effect

Bradycardia, hypertension increased intra ocular pressure.

Contraindication

i. Chronic liver disease
   ii. Malnutrition
   iii. Glaucoma
   iv. Penetrating eye injury

Non Depolarizing Blocking Agents

i. Gallamine triethiodine (Flaxadis)

Dose (Mg/Kg, IV), Dog 1.0, Cat 2.4, Horse 1.0.
Side Effects

a. Tachycardia in dogs
b. Transient decrease in arterial BP in cats.

Contraindication Renal disfunction.

ii. Pancronium Bromide (Povulon)

Dose (Mg/Kg, IV) Dog & Cat 0.04, Pig 0.1.

Side Effects Negligible

Contraindication Liver & Kidney diseases

Reversal Agents

Antagonists for muscle relaxants are presently available for non depolarising agents. These drugs are all anticholinesterase and they inhibit hydrolysis of acetylcholine and intensify the effects of acetylcholine at the neuromuscular junction.

Complications and side effects are caused by excess accumulation of acetylcholine at the neuromuscular junction. These include salivation, bronchial secretion, intestinal hypermotility and bradycardia.

The drugs used are edrophonium neostigmine, pyridostigmine the use of antagonists could be avoided if muscle relaxants are used with proper care while using muscle relaxants. Artificial respiration is recommended when respiratory exchange is inadequate. To begin with an antagonist should be administered in small doses and the concurrent administration of atrophine is necessary to alluviate side effects.

Initial Dose

<table>
<thead>
<tr>
<th>Agent</th>
<th>Antagonist</th>
<th>Atropine</th>
<th>Onset of action on muscles</th>
<th>Repeat Dose</th>
<th>Minutes between Doses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neostigmine</td>
<td>0.06 - 0.20 mg/10 kg</td>
<td>0.04 mg/kg</td>
<td>2-4</td>
<td>0.030 - 0.10 mg/10 kg</td>
<td>5-8</td>
</tr>
<tr>
<td>Edroponium</td>
<td>0.1 - 2.0 mg/10kg</td>
<td>0.04 mg/kg</td>
<td>0.5 - 1</td>
<td>0.5mg/10kg</td>
<td>2-4</td>
</tr>
</tbody>
</table>
7. GENERAL ANAESTHESIA IN RUMINANTS

In ruminants variety of surgical conditions can be completed under local and regional anaesthesia with or without sedation. Still major surgical conditions like repair of diaphragmatic hernia, repair of prepubic tendon rupture, orthopaedic surgery, thoracopericardiotomy etc. warrants general anaesthesia. The need for general anaesthesia even for simple surgical procedure depends on the clinical status and temperament of the animal, idiosyncracy and the surgical condition.

Example 1

A cow met with a road accident, was brought to the hospital. On clinical examination, part of the sacrum and first three coccygeal vertebrae were broken into small fragments. The fractured fragments were hanging out of inside through a lacerated skin wound. The animal was able to stand and walk. Multiple lacerations were also noticed on the hind quarters and the tail was severed.

In this case epidural anaesthesia between the sacrococcygeal junction or between first and second coccygeal vertebrae could not be adopted. Hence the animal was induced and maintained with general anaesthesia although the same repair could be done in a cow with intact sacrum and coccygeal.

General anaesthesia is ideal in surgical embryo collection and transfer in small ruminants because of the less stress from the donor or recipient and less handling of ovary, uterus and other associated structures for the repeated collection in valuable donors and recipients.

I. Ruminants were considered as poor subjects for General anaesthesia because of the following reasons.

A. Regurgitation

The reasons for regurgitation are

1. Reticular contraction which direct the reticular content on the cardia oesophageal sphincter.
2. Relaxation of cardia oesophageal sphincter due to anaesthetics and premedicants (except atropine sulphate)
3. Increased intraluminal pressure due to ruminal fermentation and reduced rumino-reticular motility.
4. Stimulating cough reflex during endotracheal intubation.
5. Normal negative pressure existing in the thorax which favours the siphoning of reticular ruminal content towards the cervical part of oesophagus.
6. Ruminants positioned under recumbency are more prone for regurgitation.
7. Complications during post surgical conditions due to prolonged gastrointestinal stasis.

B. Ventilation - perfusion mismatch

The ruminants are positioned under right or left or dorsal recumbency during general anaesthesia

1. Gravitational force, (higher in dependent part 0 Hypostatic congestion)
2. lack of auto regulation in lung (favours hypostatic congestion) during anaesthesia,
3. anaesthetic induced A.V. shunts (Halothane increases A.V. shunts)
4. body position (alters ventilation - perfusion mismatch due to compression atelectasis of the lung during dorsal recumbency because of transmural diaphragmatic pressure as a result of positional changes of the heavy abdominal viscera. and
5. impaired circulation due to the pressure over the major vessels like aorta and venacava leading to low central venous pressure, decreased cardiac output and coronary circulation.

C. Myositis and Neuralgia

The body weight of ruminants due to their heaviness induces compression ischemia leading to myositis and neuralgia.

D. Stress

Anaesthetic procedure induces stress, stress is the response of nervous system to noxious impulses leading to changes in hormonal status followed by catabolism. The stress factors are

1. Normal diurnal stress response
2. Stress response due to strangers (Eg. Veterinary surgeon or anaesthetist who is examining the animal is a stranger).
3. Stress response due to premedicants and anaesthetics. (The stress response as per plasma cortisol elevates from induction to recovery and the peak is at recovery. With respect to anaesthetics though halothane and isoflurane belong to the same halide group halothane induced stress is more.
4. Body position

1. Dorsal recumbency in ruminants is more stress.
2. Between right and left lateral recumbency left is more stress.

During stress one can notice increased cortisol level, increased blood glucose level and "classical stress leucogram" (leucocytosis, neutrophilia, lymphocytopenia and eosinopenia). The alterations due to stress though leads to recovery of anaesthetic patients due to catabolic metabolism it affects the immune functions. The authors feel the immune suppression, following anaesthesia as the major cause for iatrogenic diseases. Reports are available on halothane as a suppressor of NK cell activity, lower interferant levels, and synthesis of foreign proteins (leading to anaphylaxis). The increased norepinephrine levels during stress may even induce ventricular fibrillation when coronary circulation is reduced or coronary metabolism is increased or due changes in the coronary vascular resistance due to anaesthetics (Eg. intravenous bolus injection of adrenaline induces ventricular fibrillation during deep halothane anaesthesia).

E. Alterations in rumino-reticular movements and alteration in rumen fermentation

Anaesthetics and sedatives reduce the rumino-reticular function. The reduced rumino-reticular motility combined with fasting may alter the rumen fermentation pattern. During reduced gastrointestinal motility HCO₃⁻ absorption will be more. During starvation the salivary urea may tend to increase the rumen pH towards alkalosis due to hydrolysis and release of ammonia. Our previous studies on total microbial protein in foreign body reticulitis revealed about 10 fold increase than the normal may be due to total defaunation and denuded mucous membrane. When ruminal microbial population is reduced, the ammonia released by the hydrolysis salivary urea may accumulate in the rumen because ruminal microbial population is required for the trapping of ammonia and further production of ruminal microbial protein. In conditions like total defaunation the released ammonia will be absorbed in the blood stream.

GENERAL ANAESTHETIC REGIMEN IN RUMINANTS

Preparations

For elective surgery the ruminants may be fasted for 36 to 72 hours according to the level of sedation, duration of anaesthesia, surgery and post operative management (Eg. Diaphragmatic hernial repair under general anaesthesia requires more duration of fasting). The energy requirement and fluid and water requirement must be managed through intravenous routes. If surgery has to be performed to save the life of the ruminant under general anaesthesia an emergency rumenotomy can be performed as a conservative surgical intervention.
ANAESTHETIC REGIMEN

I. Tranquilizers and sedatives

A. Phenothiazine derivatives

This group of drugs depress the brain stem and are anti acetylcholine, antihistaminic and antiarrhythmic. The contraindications are

a) After recent treatment with organophosphate type anthelmintic and following organophosphorus poisoning.
b) as a tranquilizer prior to any allergic test.
c) When penis is affected.

Table showing individual drug dose and specific remarks if any.

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Name of the drugs</th>
<th>Dose</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Chlorpromazine hydrochloride (Largactil)</td>
<td>0.20 - 1.10 mg/kg I.V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.10 - 2.20 mg/kg I.M</td>
</tr>
<tr>
<td>2.</td>
<td>Triflupromazine hydrochloride (SIQUIL)</td>
<td>0.11 mg/kg I.V</td>
</tr>
<tr>
<td>3.</td>
<td>Promazine hydrochloride (SPARINE)</td>
<td>0.44 - 1.1 mg/kg I.V or I.M.</td>
</tr>
<tr>
<td>4.</td>
<td>Acepromazine maleate (PROMACE)</td>
<td>0.01 - 0.02 mg/kg I.V</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.03 - 0.10 mg/kg I.M</td>
</tr>
</tbody>
</table>

B. Benzodiazepine tranquilizers

These agents are known for their minimal alterations in cardiovascular and pulmonary function. These groups of drugs does not provide good sedation and the duration of action is very brief (Eg. Diazepam (VALIUM))

Dose: 0.25 mg/kg I.M.
0.25 - 0.50 mg/kg I.V

C. Alpha - 2 Agonists

1. Xylazine hydrochloride

Xylazine is widely used due to its safety. It is contra indicated in pregnant ruminants due to its oxytocic effect on uterus. Though xylazine functions, induces hyperglycemia reduced intestinal motility, and increases salivation, still it is the drug of choice for sedating bovines. At
this stage one should remember that xylazine induced sedation can be reversed by Yohimbine hydrochloride which is an alpha 2 competitive antagonist at the rate of 0.125 mg/kg B.W.

2. Detomidine hydrochloride

This sedative is more potent than xylazine. The dose is 10 to 20 mg/kg I.V and 20 to 40 μg/kg I.M in cattle.

II. Analgesic agents

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Drug</th>
<th>Dose</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Xylazine</td>
<td>0.1 - 0.3 mg/kg</td>
</tr>
<tr>
<td>2.</td>
<td>Detomidine</td>
<td>10 μg - 40 μg/kg</td>
</tr>
<tr>
<td>3.</td>
<td>Phenylbutazone</td>
<td>2 - 4 mg/kg</td>
</tr>
</tbody>
</table>

III. Induction agents

1. Chloral hydrate

Administered as 7% solution at the rate of 20-30 ml/45.5 kg 1% long recovery periods and lack of control on anaesthetic depth are the main disadvantages.

2. Thiopentone sodium and thiamyla

Dose - 6.60 - 8.80 mg/kg IV as 5 or 10% soln.

3. Xylazine 0.10 - 0.20 mg/kg I.M

And 10 to 15 mg/kg of ketamine in calves xylazine 0.10 - 0.20 mg/kg I.V. following by 2.20 mg of ketamine I.V in adult cattle.

4. Guaifenisin combinations

Guaifenisin 5% in Dextrose solution 5% can be combined with Xylazine 0.01% and Ketamine % 0.1

33
5. Telazol

Calves - 4.0 mg/kg I.V

6. Xylazine (0.10 mg/kg) IM followed by telazol 4.0 mg/kg.

Intubation

Cuffed endotracheal tubes are commonly used to intubate anaesthetized cattle.

Endotracheal tubes and body weight

<table>
<thead>
<tr>
<th>Weight (in lbs)</th>
<th>Cuffed tubes (mm. internal diameter)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 - 30</td>
<td>4 - 6</td>
</tr>
<tr>
<td>30 - 60</td>
<td>6 - 8</td>
</tr>
<tr>
<td>60 - 100</td>
<td>7 - 10</td>
</tr>
<tr>
<td>100 - 300</td>
<td>10 - 15</td>
</tr>
<tr>
<td>300 - 600</td>
<td>18 - 20</td>
</tr>
<tr>
<td>600 - 1000</td>
<td>20 - 25</td>
</tr>
<tr>
<td>&gt; 1000</td>
<td>25</td>
</tr>
</tbody>
</table>

Ideal inhalation agents are halothane and Isoflurane
8. GENERAL ANAESTHESIA IN HORSES

General anaesthesia in horses is an unique and complex entity, for the horse being an elite animal, easily excitable, sensitive to strange places and people making restrain and induction of anaesthesia a challenging problem for a Veterinarian. Apart from the thoraco abdominl anatomy, the muscle power and post anaesthetic complications after long surgical procedures add to the abnormal problems. However over the recent years advantageous advances had been made in equine anaesthetic techniques which are safe entailing the surgeon to resort to increased frequency of equine surgeries.

Indications

- Surgical procedure
- Cervical, pelvic or spinal radiography
- Cast application
- Special diagnostic procedures as in arthroscopy, laproscopy etc.

Factors affecting anaesthesia and selection of anaesthetic technique.

- Age, Sex and size of the horse
- Physical condition - temperament - excitability of horse.
- Type of preanaesthetic medication
- Type of surgical or diagnostic procedure
- Pre-existing disease
- Previous administration of organophosphorous, analgesic, anthelmintics.

Injectable Anaesthetics

The advantage of injectable anaesthetics are no equipment or minimal equipment, economical, quick induction and is good for short surgical and diagnostic procedure.

The disadvantages are no control over the depth of anaesthesia unless antagonists exist (Yohimbine for xylazine or detomidine). Recovery is usually, with excitement and premature attempts to stand. Long surgical and diagnostic procedure tend to change the physiological parameters. The recovery, redistribution, metabolise or excretion depends on the condition of the patients.

Requisite properties of injectable anaesthetics

The injectable anaesthetic should be potent, water soluble and does not require large volume of administration, the solution must be stable and non irritating to tissues. The onset of action increases with the increased lipid solubility. The drug should exert minimal effect on the
cardiovascular, respiratory and other vital organs apart from having wide safety margin on the organs, its metabolites non toxic to the system. The depth of anaesthesia and metabolites of the agent should not influence the disease process in the patient. The injectable anaesthetic should be rapidly metabolised or reversible with an antagonist or excreted rapidly from the system and compatible with other agents or muscle relaxants. The onset of action is decreased with the increased protein binding of the drug, the usefulness of the drug depends on the animal’s smooth or quick recovery.

**Inhalation anaesthetics**

The major advantages in inhalant anaesthetic are the control on depth of anaesthesia, excretion mainly through lungs, recovery is short, predictable safe also in impaired metabolism, availability of equipment for controlled ventilation of oxygen. Great safety for long surgical or diagnostic procedures.

Although the inhalant anaesthetic scores well over the injectable anaesthetic as compared to safety the draw back being the complex and expensive equipment required to be purchased as well as to be maintained apart from the requirement of trained personnel to operate the equipment as well as to monitor the patient.

Although many inhalant anaesthetics were in use since 16th century only a few stood the test of scientific safety standards as the following are basic properties required in an intalant anaesthetic: the gas or liquid must be non irritating. with minimal effect on the cardiovascular, respiratory and other vital organ. It should be potent, non inflammable, non explosive with wide safety margin. The high insolubility leads to rapid induction of recovery.

**Anaesthetic Protocol**

- Physical examination
- Preanaesthetic preparation
- Premedication
- Induction
- Maintenance
- Recovery
- Monitoring
- Reversal.

**Physical Examination**

The physical examination prior to preparation of the horse for premedication is mandatory to have first hand knowledge of the physical status of the animal which will help to meet any
eventuality during or after anaesthesia. Hence every effort has to be made to examine the horse as thoroughly as possible for a satisfying and successful outcome.

**General body condition:**

- Obesity, Cachexia, pregnancy, debility.

**Cardiovascular examination:**

- Heart rate and rhythm, arterial pressure, capillary refill time, auscultation for cardiac murmurs.

**Respiratory System**

- Respiratory rate and depth, mucous membrane - pallor - cyanosis, auscultation, upper airway obstruction and percussion.

**Nervous System**

- Seizures, Coma

**Metabolic and endocrine System**

- Temperature, hyper or hypothyroid, diabetes

**Musculoskeletal system**

- Weakness, electrolyte imbalance, ambulatory or non ambulatory and fractures.

**Preanaesthetic preparation**

1. Always ensure that all the drugs that are required for the anaesthesia as drugs that are to be administered, drugs for resuscitative measures are kept and checked. Decide on the type of premedicant and anaesthetic regimen to be followed.

2. Feed has to be withheld for 12 hours which will decrease the amount of fermentable ingesta in the alimentary tract. It is not advisable to fast over 12 hours as it increases the depletion of liver glycogen thereby decrease the detoxication of the anaesthetic agent. Water has to be with held 2-4 hours prior to premedication. It is advisable to administer 2-4 litres/450 kg of mineral oil prior to induction which helps in decreased fermentation of ingesta and abdominal tympany. It also prevents diaphragmatic pressure causing hypoventilation and reduced chance of post operative colic.

37
Shoes are removed and hooves are covered with bandage, the horse is clipped, groomed and wiped with a moist cloth. The mouth is rinsed with sterile water. The surgical area is prepared by clipping, shaving and scrubbing if the horse is cooperative. The position of the animal after anaesthesia and enough padding material for head, shoulder and hip are important. Water mattresses are the best which will prevent post anaesthetic Rhabdomyolysis.

**Premedication**

Administration of premedicant drugs facilitate in reduced requirement of general anaesthetic as well prepare the animal to be calm and adjust to the new environment and surgeons in the operation theatre. Premedication lengthens or promotes smoother recovery from anaesthesia and decrease the minimum alveolar concentration for inhalation agents. Most commonly used premedicants in equine are acepromazine, xylazine, Butorphanol and detomidine apart from administration of glycopyrrolate or atropine as antimuscarinic agent. The above drugs are administered in combination to reduce their dose regimen and inturn to potentiate the anaesthetic agents for beneficial effects.

### PRE ANAESTHESIA DRUGS

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Drug</th>
<th>Dose mg/kg</th>
<th>Route</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Chlorpromazine</td>
<td>1.1 - 2.2</td>
<td>Iv, Im</td>
<td>Full depression 5-15 min lasting 5-8 hrs.</td>
</tr>
<tr>
<td>2</td>
<td>Triflupromazine</td>
<td>0.22 - 0.44</td>
<td>Iv, Im</td>
<td>45-60 mts. lasting 12-18 hrs.</td>
</tr>
<tr>
<td>3</td>
<td>Promazine HCl</td>
<td>0.44 - 1.1</td>
<td>Iv, Im</td>
<td>Onset 10-20 mts Iv</td>
</tr>
<tr>
<td></td>
<td></td>
<td>35.9 - 71.7</td>
<td>Oral</td>
<td>Onset 45 mts.</td>
</tr>
<tr>
<td>4</td>
<td>Acepromazine</td>
<td>0.044 - 0.088</td>
<td>Iv, Im</td>
<td>Onset 15-20 mts</td>
</tr>
<tr>
<td>5</td>
<td>Diazepam</td>
<td>0.02 - 0.1</td>
<td>Iv, Iv</td>
<td>For adults - Seizures</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.1 - 0.15</td>
<td></td>
<td>foals - seizures</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.11 - 0.44</td>
<td>Iv</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Xylazine HCl</td>
<td>0.44 - 0.55</td>
<td>Iv, Im</td>
<td>Standing sedation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.88 - 0.1</td>
<td></td>
<td>Preanaesthetised to ketamine</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.1</td>
<td></td>
<td>or talazol</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.33 - 0.66</td>
<td>Iv</td>
<td>Foals</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.44 - 0.55</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.88 - 1.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Acepromazine + Xylazine</td>
<td>0.44</td>
<td>Iv</td>
<td>10 mts after acepromazine</td>
</tr>
</tbody>
</table>
### Injectable Anaesthetics

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Drug</th>
<th>Dose mg/kg</th>
<th>Route</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.</td>
<td>Xylazine + Butorphanol</td>
<td>0.01 - 0.5</td>
<td>Iv</td>
<td>5 mts after xylazine</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.01 - 0.04</td>
<td>Iv</td>
<td></td>
</tr>
<tr>
<td>9.</td>
<td>Xylazine + Morphine</td>
<td>1.2</td>
<td>Iv</td>
<td>5 mts after xylazine, naloxane</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.75</td>
<td>Iv</td>
<td>9.9 mg/kg reversal for morphine</td>
</tr>
<tr>
<td>10.</td>
<td>Detomidine</td>
<td>20 - 40 mg/M</td>
<td>Iv</td>
<td>standing restraint with ketamine with the combinations</td>
</tr>
<tr>
<td></td>
<td></td>
<td>22 - 44</td>
<td>Iv</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.4 - 11.0</td>
<td>Iv</td>
<td></td>
</tr>
<tr>
<td>11.</td>
<td>Detomidine + Butorphanol</td>
<td>10.0</td>
<td>Iv</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.05 mg</td>
<td>Iv</td>
<td></td>
</tr>
<tr>
<td>12.</td>
<td>Detomidine + Morphine</td>
<td>10.0</td>
<td>Iv</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.1</td>
<td>Iv</td>
<td></td>
</tr>
<tr>
<td>13.</td>
<td>Atropine</td>
<td>0.0165 - 0.02</td>
<td>Iv/Im/Sc</td>
<td>Atropine not used routinely</td>
</tr>
<tr>
<td>14.</td>
<td>Glycopyrrolate</td>
<td>0.005</td>
<td>Iv/Im/Sc</td>
<td>This dose does not cause ileus glycopyrrolate is preferable.</td>
</tr>
</tbody>
</table>

**Induction**

After premedication and the desired effect seen the animal is induced for general anaesthesia. All precautions to be taken and be prepared to restrain the animal after induction and the required position of the animal for surgery and the padding of the animal. Many drugs have come to stay and the safety of margin also increased with the advent of newer drugs and their combinations.
5. Xylazine + Ketamine 1.1 Iv 5-15 mts anaesthesic
   1.76 - 2.2 Iv 20 mts recumbency

6. Diazepam + Zylazine + Ketamine
   0.22 - 0.33 Iv 20 mts prior to xylazine
   1.1 Iv
   1.76 - 2.2 Iv

7. Xylazine + Diazepan + Ketamine 1.1 Iv
   0.022 Iv Simultaneously after xylazine
   2.2 Iv 20-25 mts anaesthesia

8. Xylazine + Butorphanol + Ketamine 1.1 Iv
   0.04 Iv Simultaneously followed by Ketamine
   2.2 Iv 20-25 mts anaesthesia

9. Detomidine + Ketamine 22 mg/M Iv Ketamine after 5-10 mts
   2.2 mg/m Iv 25 mts anaesthesia

10. Xylazine + Guaiifenesin 5% + Ketamine 1.1 Iv
    1.1 Iv 15-20 mts highest anaesthesia
    1.32 - 1.76 Iv 30-40 mts recumbency

11. Xylazine + Guaiifenesin 5% + Ketamine 0.33 Iv
    1.1 Iv
    2.2 Iv

   or with acepromazine 0.02 - 0.044 Iv A + G + K
   5-10 ms/m Iv D + G + K
   or Detomidine

As infusion - premedicate with xylazine, acepromozine or detomidine, ketamine 1 gm mixed with 5% guaiifenesin 1 ltr - rapidly administered to produce recumbency. Or Xylazine 0.5 mg/m (0.05%) 5%. Guaiifenesin 50 mg/ml and ketamine 1.0 - 2.0 mg/ml (0.1 - 0.2%) infused to induction/maintenance 2-3 ml/kg/hr.

Inhalation anaesthesia

Following administration of premedicant drugs and the desired effect is obtained the animal can be induced with injectable anaesthesia and then maintained under inhalation or can be induced and maintained under inhalation anaesthesia.

The animal is intubated with right size endotracheal tube and the cuff enlarged and connected to the anaesthetic apparatus. The size of the endotracheal tube can be selected on the basis of body weight.
With halothane the vaporiser is set at 4-5%, oxygen 17.6 ml/kg/min. It takes 5 mts (5%) or 10 mts (4%). When the upper eye lid begin to close, the vaporiser setting is reduced to 4 or 3% and another 5 mts for palpebral reflex to be just present or absent, the percentage decreased to 2.5%. For maintenance 1.5 - 2.5% halothane with 8.5 - 13.2 ml/kg/mts to maintain isoflurane 2-3% with oxygen 8.8 - 13.2 as it is less potent, less soluble than halothane. Methoxyflurane at 3% with oxygen 17.6 ml/kg/min and 1-2% for maintenance.

**MONITORING**

Treatment of anaesthetic emergencies and recovery complication are more difficult and unrewarding and hence emphasis is on prevention along with therapy. The patient’s response to anaesthesia is monitored by monitorig the changes in CNS, cardiovascular and respiratory systems. Anaesthetic agents produce dose related cardiovascular depression.

**NORMAL VALUES FOR ANAESTHETISED ADULT/FOAL**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Adult</th>
<th>Foal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Respiratory Rate</td>
<td>6-12</td>
<td>10-20 breath/min</td>
</tr>
<tr>
<td>Tidal Volume</td>
<td></td>
<td>11.0 ml/</td>
</tr>
<tr>
<td>Heart Rate</td>
<td>30-50</td>
<td>50-70 beats/min</td>
</tr>
<tr>
<td>Gingival perfusion time</td>
<td>1-2 Sec.</td>
<td></td>
</tr>
<tr>
<td>Arterial pressure systolic/diastolic</td>
<td>90-130/65-85</td>
<td>80-110/50-75 mm Hg</td>
</tr>
<tr>
<td>Mean arterial pressure</td>
<td>75-100</td>
<td>65-90 mm Hg</td>
</tr>
<tr>
<td>Central venous pressure standing/dorsal/lat. recumbancy</td>
<td>5-10 cm H$_2$O</td>
<td>10-30 cm H$_2$O</td>
</tr>
</tbody>
</table>
Anaesthetic overdosage induces deterioration in cardiovascular variables. Cardiovascular system is assessed through cardiac output, arterial pressure, pulse strength, heart rate, gingival perfusion time, colour of mucous membrane. ECG and central venous pressure. Unlike other animals horse maintain normal heartrate range as depth of anaesthetic increase and if horse fail to compensate, little time for anaesthetist to react to impending cardiac arrest or other complication. Colour of gingival mucous membrane and capillary refill time are indicators of tissue perfusion. Cyanosis is indicative of haemoglobin decreasing to 5g/dl.

FLUID ADMINISTRATION

Ringer lactate or any polyionic isotonic solution with an alkaliising effect should be administered rapidly during early post induction stage of anaesthesia as the horse is hypotensive. Once normal blood pressure reaches, 4.4 - 6.6 ml/kg/hr is maintained and 11.0 ml/kg/hr. prevents surgical shock and anaesthesia related vasodilation. In critical cases 12.0 L/hr is maintained so as to maintain haematocrit above 25%.

RECOVERY

For uneventful recovery the horse should always be assisted or restrained when it tries to stand prematurity and the recovery stall has to be well padded and nonslippery, the lights should be dimmed or switched off, free from disturbance or noise or otherwise a hood can be placed. If recovery is violent xylazine can be administered to assist in smooth recovery. Horses under isoflurane recover smooth and quick as compared to halothane. Feed should be withheld for 2 hours to minimise Choke. Endotracheal tube is removed once the laryngeal reflex returns.

When the horse is under inhalation anaesthesia 10 mts prior to completion of surgery the controlled ventilation is reduced to 50% to allow carbon dioxide to accumulate and spontaneous ventilation to resume. Nitrous oxide is discontinued 10 mts prior to disconnecting oxygen.

Anaesthetic vaporiser is turned off nearing the completion of surgical procedure and depends on the depth of anaesthesia.

ANAESTHESIA - SPECIFIC CONDITION

Acute abdominal disease - colic. In a good physiological condition horse, there will be normal to moderate increase in PCV, plasma protein and heart rate, strong peripheral pulse, pink mucous membrane and none to moderate tympany.

Although xylazine, detomidine or butorphanol cause hypotension, these drugs can be administered in small amounts. Phenothiazine tranquilizers are contraindicated and if used the horse has to be monitored for hypovolemic shock. The horse has to be intubated with nasogastric
tube to avoid regurgitation. As far as possible avoid atropine or glycopyrrolate as these drugs cause ileus. Halothane or isoflurane are the choice of anaesthetic. The horse can be induced with xylazine, ketamine or ketamine-guaifenisin. Nitrous oxide avoided and contraindicated in hypoxemia and obstruction loops of bowel. The head is lowered, as regurgitation occurs as the cardiac relaxes with anaesthesia. Five minutes prior to surgery butorphanol 0.022 IV can be administered for additional analgesia. Fluids are administered as per the condition of the horses.

In a poor physiological condition horses there is elevated heart rate, weak thready pulse, cyanosis, prolonged gingival perfusion time (3-5 sec.) depressed, marked dehydration and severe abdominal tympany. The protocol include control of pain with minimum sedation, animal stabilised with intravenous fluids in large quantities and acidemia counteracted with administration of sodium bicarbonate. Horse in poor physiologic condition, administration of barbiturates is contraindicated due to existing acidemia and shock.

Halothane or isoflurane 1-3% can be administered, for additional analgesia, butorphanol 5 mts. prior to surgery. Atropine and glycopyrrolate are not advisable. Xylazine is administered at 0.22 - 0.44 hr for smooth recovery.

When recovery is violent after surgery, find the cause may be due to abdominal pain or myopathy pain or acidemia and correct when no preanaesthetic tranquilizer is used.

UROPERITONIUM

Usually in neonatal foals. There is abdominal distension, hypovolemia, hypochloremia, hyponatremia, hyperkalemia, acidemia, dysarthria. Normal saline is administered to restore blood volume with insulin 0.1g/kg and dextrose 0.5g/kg to decrease potassium.

Abdomen is compressed prior to surgery to avoid precipitation of shock during surgery. Halothane or isoflurane is preferred. Warm water circulating blankets to control hypothermia.

Dystocia and caesarian

Mares often in compromising physical status are referred. After stabilising with fluids the mare can be induced or maintained with Guaifenesin + ketamine and Isoflurane or otherwise with Xylazine + ketamine + Guaifenesin

Laceration or extensive damage to musculo skeletal system

Phenothiazines are contraindicated due to hypotensive effect. Administration of large volume of fluids. General anesthesia is induced and maintained with Xylazine + Ketamine + Guaifenesin.
Fractures

Every care is taken to apply splint bandage or atleast Robert smith bandage and when the animal is being restrained for surgery the affected leg should be the up limb, to avoid further complicating the fracture.

Anaesthesia in Neonatal foal

The general indication for sedation are radiography, catheter placement, minor laceration, treatment of joining, fluid aspiration peritoneal lavage, or premedication to General Anaesthesia.

General anaesthesia is indicated for artificial respiration and respiratory disorders. In major surgery such as uroperitonium, musculoskeletal trauma and fracture, Gastro Intestinal emergencies, ocular trauma, congenital (Cleft palate) and infected umbilicus.

The characters that influence the anaesthetic management in neonatal equine are cardiovascular, respiratory, thermoregulatory, energy store, renal function, fluid balance, hepatic and CNS as the developments is not as seen in the other neonates.

Sedative

<table>
<thead>
<tr>
<th>S.No</th>
<th>Agents</th>
<th>Dose mg/kg</th>
<th>Route</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Acepromazine</td>
<td>0.02 - 0.04</td>
<td>IV/IM</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Promazine</td>
<td>0.25 - 0.70</td>
<td>IV/IM</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Dizepam</td>
<td>0.05 - 0.44</td>
<td>IV</td>
<td>(Slow)</td>
</tr>
<tr>
<td>4.</td>
<td>Lorazepam</td>
<td>0.02 - 0.05</td>
<td>IV</td>
<td>(Slow)</td>
</tr>
<tr>
<td>5.</td>
<td>Droperidol</td>
<td>0.2 - 0.5</td>
<td>IV</td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>Azaperone</td>
<td>0.25 - 0.5</td>
<td>IV</td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>Butorphanol</td>
<td>0.01 - 0.04</td>
<td>IV</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.02 - 0.08</td>
<td>IM</td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td>Morphine</td>
<td>0.05 - 0.1</td>
<td>IV/IM</td>
<td>Reverse with nolaxan 0.01-0.2 IV Larallopia 0.02 - 0.04 IV (Lorfan)</td>
</tr>
<tr>
<td>9.</td>
<td>Meperidine</td>
<td>0.5 - 1.0</td>
<td>IV/IM</td>
<td></td>
</tr>
<tr>
<td>10.</td>
<td>Xylazine</td>
<td>0.1 - 0.5</td>
<td>IV</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.25 - 1.0</td>
<td>IM</td>
<td></td>
</tr>
<tr>
<td>11.</td>
<td>Detomidine</td>
<td>10 - 40 μg/Kg</td>
<td>IV</td>
<td></td>
</tr>
</tbody>
</table>
12. Diazepam + Ketamine 0.1 - 0.2 (slow) 1 - 2 (Slow) IV IV After 5 mts Ketamine

13. Xylazine + Ketamine 0.25 - 0.5 1 - 2 IV IV Wait 5 mts

14. Thiopentone/thiarylal 4 - 10 IV 2.5% or 5% no premedication necessary

15. Pentobarbital 5 - 10 IV 5% or 6% maintenance 1 - 3 mg/kg

16. Guaifenesin/thioburbiturate 25gms IV 5% solution with 1 gm thiopentol or thyamal

Post operative Rhabdomyolysis

Post operative rhabdomyolysis is one of the major post anesthetic or post operative complication mainly due to extended period of general anaesthesia or prolonged recumbency.

It is also known as myopathy, radial paralysis post anaesthetic forelimb lameness, post operative myopathy and triceps rhabdo myolysis due to localised compression of muscle and compromise of circulation.

In dorsal recumbency muscles of the back, longissimus, iliacostal, gluteul medius or vastus lateralis muscles are affected.

In lateral recumbency triceps brachii, quadriceps femoris, hindlimb extension muscles or flank muscles are affected.

Mostly the 'down' limb is effected and occasionally the upper limb due to over hanging of the limb from the edge of the operating table or criscrossed position, resting on the lower limb without being supported by a leg stand, the weight of the animal press on the contact limb leading to tissue hypoxia which inturn leading to myopathy localised swelling, increased pressure, decreased capillary blood flow leads to muscle degeneration. The myopathy is also due to compartment like syndrome due to increased intracompartmental pressure (30 -50 to 80 mm Hg)

When the fore limb is affected dropped elbow appearance like radial paralysis but can use extensors, when hind limb is affected fetlock knuckling and stifle drop is seen in quadriceps femoris affection. The treatment of rhabdomyolysis is prevented by less anesthetic. It has been proved that water mattresses are the best choice. In recumbency lower limb is pulled to reduce pressure on triceps brachii muscle upper limb is elevated with a limb stand.
9. GENERAL ANAESTHESIA IN PIGS

Swine presents some special problems to the Anaesthetist. The various problems encountered are:

i. Difficult to restrain
ii. Fewer accessible superficial veins and arteries
iii. Tracheal intubation is difficult
iv. Higher incidence of malignant hyperthermia
v. Intramuscular injections may be ineffective in large fat swines.

The route of administration are intravenous (base of the ear) intraperitoneal (1 inch lateral to the midline in the area posterior to the umbilicus and anterior to the pubis) intramuscular (neck) and intratesticular (for injection of pentobarbital).

Phenothiozine tranquillizer like acepromazine (0.11 - 0.4 mg/kg with a maximum of 15 mg total dose) and promazine (0.44 - 1.1 mg/kg) IV or IM is well suited in pigs.

Xylazine can be used as premedicant at the dose of 1.1 - 2.2 mg/kg. Innovar-vet is administered at the rate of 1.0 ml/9 - 14 kg bodyweight intramuscular.

Preanesthetic preparation

i. With hold feed for 12 hours and water for 6 hours.
ii. Atropine can be administered at the rate of 0.044 mg/kg, 10 - 20 minutes prior to induction.

Induction

i. Thiopental and thiamylal can be administered as a 5% solution at 6.6 - 8.8 mg/kg through ear vein.

ii. Pentobarbital is administered at the rate of 26.0 mg/kg intravenously. Half of the calculated dose is injected rapidly and the remainder to abolish the pain reflex.

iii. Ketamine can be administered at the rate of 20.2 mg/kg intramuscularly in atropine premedicated pigs. (0.04 mg/kg).
iv. Acepromazine - Ketamine

Acepromazine is given at the rate of 0.4 mg/kg intramuscularly followed 30 minutes later by Ketamine 15.0 mg/kg intramuscularly. The duration of anaesthesia is 60-90 minutes.

v. Xylazine - Ketamine

Xylazine at the rate of 1.1 - 2.2 mg/kg intramuscularly minutes prior to ketamine at 11-15 mg/kg intramuscularly. Duration of anaesthesia is 30-45 minutes.

vi. Xylazine - Butorphanol - Ketamine

Combination of xylazine 2.2 mg/kg butorphanol 0.22 mg/kg and ketamine 11.0 mg/kg can be administered intramuscularly to provide anaesthesia.

vii. Xylazine - Guaifenesin - Ketamine

Guaifenesin 5%, Ketamine 0.1% and xylazine 0.1% in 5% dextrose solution can be used as induction and maintenance agents in swine at the rate of 0.5 - 1.0 ml/kg intravenously for induction.

viii. Xylazine (2.2 mg/kg) and telazole 6.0 mg/kg can be given intramuscularly in juvenile swine to provide anaesthesia for approximately one hour.

ix. Inhalation agents like halothane, isoflurane and methoxy flurane have been used for mask induction.

Normal Values for Anaesthetized Swine

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart Rate</td>
<td>80-130 beats/minutes</td>
</tr>
<tr>
<td>Respiratory Rate</td>
<td>10-25 breaths/minutes</td>
</tr>
<tr>
<td>Arterial pressure</td>
<td>80-120 mm Hg Systolic</td>
</tr>
<tr>
<td>Central Venous Pressure</td>
<td>5-10 cm H$_2$O</td>
</tr>
<tr>
<td>Diastolic</td>
<td></td>
</tr>
</tbody>
</table>

Malignant Hyperthermia

In pigs malignant hyperthermia is related to genetic functional defect resulting in the accumulation of calcium within the myoplasma. This muscular defect is associated with abnormal calcium flexes, increased muscular enzyme activity and heat and carbon dioxide production. The other causes for malignant hyperthermia are high metabolic activity associated with light levels
of anaesthesia, large or obese patients, insulation by surgical draping and breathing fully humidified gas mixture.

**Treatment**

i. Hyperthermic patients should breath an enriched oxygen mixture.

ii. Rapid administration of crystalloid fluids

iii. Corticosteroids and sodium bicarbonate administration

iv. Inducing conductive heat loss by placing ice water packs or by immersing the patient in cold water or ice water bath.

v. Antipyretics can be administered

vi. Dantrolene sodium reduces the mortality due to hyperthermia.
10. GENERAL ANAESTHESIA IN DOGS

Anesthetic Management of normal young or old and traumatized or critically ill patient are challenging and the success depends on good understanding of anesthetic pharmacology, normal physiologic function, acid-base balance, fluid and electrolyte therapy, proper monitoring techniques and pathophysiology associated with ageing or disease process.

Selection of preanesthetic and anesthetic combination and need for adjunct medications such as blood, electrolyte solution, corticosteroid, oxygen etc. depends on various factors like animal status, surgical procedure and anesthetist experience with the drugs. There is no single anesthetic drug or procedure available for all conditions of the animal. The success of anaesthesia depends on the anesthetic managements which includes preanaesthetic evaluation of patients selection of anaesthetic regime and post anaesthetic monitoring.

PREANAESTHETIC CONSIDERATION

Preanaesthetic evaluation consists of thorough history, physical examination and laboratory result. These detailed observations helps in assessing the status of the animal and thereby fixing anesthetic regime for the animal. A check list of observations should prepared before subjecting the animal to anaesthesia. The check list should contained the following:

I. History

1. Age : Neonatal and Geriatric patients may need only 15 to 30% of tranquillizers dose of young healthy dogs.
2. Breed : Brachycephalic breeds prone for airway problems during anesthesia.
3. Sex : A female dog in estrous cycle will bleed more.
4. Body Weight : Small dog will have more surface area and consume more anesthetic due to higher basal metabolic rate.
5. Duration of Ongoing Complaint
6. Concurrent Medication : Aminoglycosides will potentiate the action of non-depolarising muscle relaxant group. Chloramphenical increases the recovery time of barbiturates.
8. Previous anesthesia and allergies.
9. Duration of Fasting : Helps in assessing the energy and fluid status of the animal.
II. Physical Examination

1. **Body Condition**: Obese animal consume more anesthetics. Dehydrated animal need fluid therapy. Cachexic patient anaesthetized with less amount of anesthetics due to hypoproteinemia.
2. **Cardiopulmonary Status**: Xylazine is contraindicated in cardiac patient due to its suppression effect. Barbiturates should be avoided in respiratory depression.
3. **CNS**: Temperamentally excited dogs will have lesser tranquilizing effect. Epileptic patient need diazepam as premedication for anticonvulsant effect.
4. **Abdominal Palpation**: It may reveal enlarged liver or spleen or kidney and tumours in the abdomen.

III. Laboratory Evaluation

Minimum routine laboratory test for normal young animal consists of PCV and plasma protein. For older animal with or without organ dysfunction specific laboratory test like BUN, creatine, SGOT, potassium etc. should be conducted according to the status of the animal before subjecting the animal to anaesthesia. Same may be repeated during post anaesthetic period for some specific disease to rule out anaesthetic effect on organ function.

During preanaesthetic evaluation if any animal found to be suffering from any one of the following condition should be corrected before anesthesia. They include (1) severe dehydration (2) anemia (or) hypoproteinemia PCV < 20%, Albumin < 2 gm/dl (3) acid base and electrolyte disturbances pH < 7.2, Potassium < 2.5 (or) > 6.0, (4) pneumothorax (5) cyanosis (6) oliguria (or) anuria (7) congestive heart failure (8) severe life threatening cardiac arrhythmias.

**PREPARATION OF PATIENT**

The dogs should be fasted minimum 6 hours prior to anesthesia. The animal should be allowed to take water until just prior to anaesthesia. Young dogs less than 18 weeks and dogs weighing less than 2 Kgs should not be fasted more than 2 hours. The dog which is going to be subjected to anaesthesia for more than 15 minutes should be prepared for intravenous infusion.

**ANAESTHETIC CONSIDERATION**

Selection of a particular anaesthetic regimen depends on the patient needs rather than routine administration. Patient's age, physical status, temperament, type of surgical procedure and its duration and availability of assistance, facility and equipment should be considered before selecting the anesthetic regimen.
COMMON PREANESTHETICS AND ANAESTHETICS USED IN DOG

<table>
<thead>
<tr>
<th>Drug</th>
<th>Dosage mg/kg and Route</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>I. SEDATIVES &amp; TRANQUILIZERS</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acepromazine</td>
<td>0.02 - 0.2 I/M I/V S/C</td>
<td>Mild to moderate sedation of 1 to 2 hour duration</td>
</tr>
<tr>
<td>Xylazine</td>
<td>0.3 - 2.2 I/M I/V</td>
<td>Moderate to deep sedation. 20 min - 1 hour duration with analgesia and mild muscles relaxant effect.</td>
</tr>
<tr>
<td>Diazepam</td>
<td>0.2 - 0.4 I/V I/M</td>
<td>Anticonvulsant, mild sedation, good combination with ketamine</td>
</tr>
<tr>
<td><strong>II. OPIOIDS</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Morphine</td>
<td>0.2 - 0.6 I/M S/C</td>
<td>Mild sedation, duration of analgesia 1-4 hours</td>
</tr>
<tr>
<td>Oxymorphine</td>
<td>0.05 - 0.1 I/M S/C</td>
<td>Excitement in healthy dog. Duration of analgesia 1-4 hours</td>
</tr>
<tr>
<td>Pentazocine</td>
<td>1 - 1.5 I/M I/V S/C</td>
<td>Duration of analgesia 30 mts - 1 hr with mild sedation</td>
</tr>
<tr>
<td><strong>III. INJECTABLE ANAESTHETICS</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ketamine</td>
<td>10.00 I/V</td>
<td>Increase muscle tone. Short duration 5-20 mts.</td>
</tr>
<tr>
<td>Telazol</td>
<td>10.00 - 20.00 I/M I/V</td>
<td>Satisfactory anesthesia, rougher recovery, duration 20-80 mts.</td>
</tr>
<tr>
<td>Thiopental</td>
<td>10.00 - 20.00 I/V</td>
<td>Duration 20-30 minutes</td>
</tr>
<tr>
<td>Thiopental</td>
<td>6.0 - 15.0 I/V</td>
<td>Duration 20-30 minutes</td>
</tr>
<tr>
<td>Propofol</td>
<td>4.0 - 6.0 I/V</td>
<td>Rapid recovery, duration 5-10 mts.</td>
</tr>
<tr>
<td>Etomidate</td>
<td>0.5 - 2.0 I/V</td>
<td>Myoclonus, retching common. Duration 5-10 minutes.</td>
</tr>
<tr>
<td><strong>IV. MUSCLE RELAXANTS</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Succinylchloride</td>
<td>0.2 to 0.4</td>
<td>Duration 10 - 20 mts.</td>
</tr>
<tr>
<td>Gallamine</td>
<td>1.0</td>
<td>15 - 20 mts.</td>
</tr>
<tr>
<td>Pancuronium</td>
<td>0.05 - 0.1</td>
<td>45 to 60 mts.</td>
</tr>
<tr>
<td><strong>V. COMBINATIONS</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ketamine/Diazepam</td>
<td>5.5 / 0.20 I/V</td>
<td>Poor muscle relaxant 5-10 mts. restraint</td>
</tr>
<tr>
<td>Ketamine/Xylazine</td>
<td>10.0 / 1.0</td>
<td>Duration 20-40 mts.</td>
</tr>
<tr>
<td>Ketamine/Acepromazine</td>
<td>10.0 / 0.2</td>
<td>Duration 20-30 mts.</td>
</tr>
<tr>
<td>Etomidate/Diazepam</td>
<td>1.5 - 3.0 / 0.2</td>
<td>Duration 30 - 40 mts.</td>
</tr>
<tr>
<td>S.No.</td>
<td>System / Organ Dysfunction</td>
<td>Anaesthetic Regimen</td>
</tr>
<tr>
<td>-------</td>
<td>----------------------------</td>
<td>---------------------</td>
</tr>
<tr>
<td>I.</td>
<td>Cardiovascular Dysfunction</td>
<td>No Atropine</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Low doses of acetylpromazine &amp; Narcotic analgesics</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Thiopental Sodium</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Isoflurane, Nitrus oxide and oxygen</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Muscle relaxant if needed</td>
</tr>
<tr>
<td>II.</td>
<td>Respiratory Disease</td>
<td>No narcotics</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Low doses of acetyl promazine and diazepam</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Thiopental Sodium</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Halothane or Isoflurane</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No Nitrous Oxide</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ventilation with high concentration of oxygen</td>
</tr>
<tr>
<td>III.</td>
<td>Hepatic Dysfunction</td>
<td>Ketamine &amp; Diazepam</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Propofol</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mask Induction and Maintenance with isoflurane Nitrous oxide and oxygen</td>
</tr>
<tr>
<td>IV.</td>
<td>Renal Disease</td>
<td>Acepromazine and Thiobarbiturate</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mask induction and maintenance with isoflurane</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Diuretics and I/V fluid</td>
</tr>
<tr>
<td>S.No.</td>
<td>System / Organ Dysfunction</td>
<td>Anaesthetic Regimen</td>
</tr>
<tr>
<td>-------</td>
<td>---------------------------</td>
<td>--------------------</td>
</tr>
<tr>
<td>V.</td>
<td>Neurologic Disease</td>
<td>No dissociative, halothane, enflurane and nitrous oxide</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Benzodiazepine tranquilization</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Thiobarbiturate Induction Maintenance with Isoflurane</td>
</tr>
<tr>
<td>VI.</td>
<td>Caesarean Section</td>
<td>Diazepam &amp; Etomidate</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Diazepam, Ketamine and Isoflurane</td>
</tr>
</tbody>
</table>

Monitoring during anaesthesia and postanaesthetic period is dealt in detail elsewhere in this manual.
11. GENERAL ANAESTHESIA IN WILD ANIMALS

The veterinary practitioner is often called upon for chemical restraint of non domestic animals. Inhalant anaesthetics can be used in most of the species safely but require injectable anaesthetics for induction. The injectable agents are administered by a hypodermic syringe, dart gun, blow dart, pole syringe. In wild and exotic species restrain leads to excitation and stress which may cause shock and death. The use of the drug delivery equipments has its own disadvantages as sometimes the needle may break or impaction, or inaccurate impact, weak propelling charge, drug leak etc. This chapter deals in brief to some of the wild and exotic species anaesthetic regimen and the reader is advised to refer standard text books for detailed information.

Primates

The most commonly administered agent for immobilising primates is with Ketamine 8 - 10 mg/kg IM for minor procedure and 15-25 mg/kg IM for surgical anaesthesia. Small primates require 20-25 mg/kg IM, for medium primates 10-15 mg/kg IM and great apes 6-10 mg/kg IM.

Exotic Feline

For 15-20 mts immobilisation 10-15mg/kg IM and Xylazine 2 mg/kg IM is the drug of choice the same regimen can be used for maintenance. Small cats 20-30mg/kg Ketamine IM, medium sized cats 10-20 mg/kg and large cats 5-10mg/kg. Care is taken in large cats as they are easily aroused by auditory, visual and physical stimuli at low doses.

Exotic Canids

Anaesthesia 15-20mts can be achieved with Ketamine 10mg/kg IM and Xylazine 2mg/kg IM and maintained with inhalation agents or same Anaesthetic regimen.

Zebras, Elephant and Rhinoceros

Etorphine hydrochloride is the drug of choice and the antagonist being diprenorphine given intravenously twice the dose of etorphine administered for reversal. A commercial mixture of etorphine-acepromazine 2.45mg/ml etorphine and 10mg/ml of acepromazine (Immobilon-large animal) is used to sedate Asian Elephants with 1ml/4 feet of shoulder height. Etorphine dose for
elephants 4 - 8 mg IM total dose and for Rhinoceros 2-4mg IM and Zebra 2-5mg IM Xylazine 0.08 - 0.15 mg/kg IM can be used for smooth immobilisation for minor procedures in elephants.

**Camels and Deer**

In camels Xylazine 0.2 - 0.5 mg/kg IM. A mixture of guaifenesin 110mg/kg and thiopentol 4.4mg/kg for induction through intravenously and for maintenance 5% guaifenesin in 5% Dextrose with thiopentol (2mg/ml) can be given to 'effect'.

For Giraffe 0.3-0.4 mg/kg of Xylazine with 1.5-2mg total dose of etorphine is administered in Deer etorphine 2mg/100kg and Xylazine 30 mg/100kg or fentanyl 0.3- 0.66 mg/kg and Xylazine 0.5-1.3mg/kg intramuscular is effective combination. For transportation of deer chlorpromazine 4.4 mg/kg IM gives good results.

**Hippopotamus**

Etorphine can be administered at a total dose of 4-8 mg above or in combination with Xylazine 0.1 mg/kg IM.

**Bears**

Ketamine 4.5-9.0 mg/kg with Xylazine 2.0-4.5 mg/kg IM produces good anaesthesia.

**Free ranging animals**

The free ranging animals are captured unharmed for marking, sampling, translocation, medical treatment and research. The technique of capturing free ranging animals developed from the use of hunting with curve tipped arrows to the present day use of modern drugs with more improved gun delivery systems. Stress plays an important role while the animal is captured and depends on the mode and anaesthetic techniques. Some of the drug delivery equipments in use are the pole syringe, blow gun, power projection system in the form of rifles and pistols, power charged projectors fired from a 0.22 calibre changes to propel the drug dart. Carbon-di-oxide powered in projection uses gas from a carbon-di-oxide cartridge to propel the drug dart. And the compressed and powered projectors utilise compressed air from a tank to propel the dart.
Etorphine is the most commonly used drug available as 2.45 mg/ml etophine with 10 mg/ml acepromazine (L.A. immobilon) and 0.07 mg/ml etorphine with 18 mg/ml methotrimeprazine (S.A. immobilon) game immobilisation contains 9.8 mg/ml etorphine. Etorphine is very effective in ungulates, rhinoceros and elephant.

Ketamine, Xylazine and Telazol, detomidine are some of the drugs which are in use in combination. Phenothiazine are not used due to hypotension and causing disturbances in thermoregulatory mechanism.
12. GENERAL ANAESTHESIA IN BIRDS

The increasing domestication of variety of birds necessitates the veterinarian to be per force conversant with the management of anaesthetic techniques as well as restraint technique in birds. The birds are very susceptible to shock due to stress during restraint leading to cardiac arrest. The constrain in anatomical configuration due to incomplete diaphragm and phenomenic sack are a disadvantage for the veterinarian in the management of restraint and anaesthetic technique.

The smaller size of the bird preclude monitoring of various physiological parameters. Loss of even 5 drops of blood in a small bird is about 15% of the total blood volume may lead to severe hypotension or sometime cardiac arrest. The major disadvantage in avian general anaesthesia being hypothermia due to heat dissipation as bird have high surface to volume ratio which decrease the respiratory rate.

General consideration

The anaesthetic technique depends on the species of the bird, age, weight, amount of body fat condition of the bird and surgical procedure. Birds in shock, ascites, severe anaemia, respiratory distress, fluid filled crop dehydration and acidosis are poor subjects for anaesthesia and general anaesthesia is contraindicates.

The complete physical examination or assessment of various physiological parameters are required prior to anaesthetic induction. Generally the birds take about 2-5 minute to return of normal respiration after capture. Birds with 25-30 PCV requires blood transfusion and greater than 50 - 60 demands fluid administration, subcutaneously in small bird and intraneously in large birds (5 ml/kg/hour).

Preparation of bird for anaesthesia

Fasting prior to anaesthesia is not advisable especially in smaller birds. Medium sized birds are fasted for 2 hours whereas large sized birds are fasted upto 6 hours. Warm blanket or towels are required to be wrapped around the bird to present hypothermia which depress respiratory system. Pigeon is the universal donor in birds for blood transfusion and provision has to be made to keep heparnised blood for transfusion when blood loss is anticipated during or after surgery.
The bird is restrained by holding the wings to the back and legs with a tape. Long necked birds (gana) the neck also should be controlled.

Anaesthetic administration

Anaesthetic agents are administered in increments of minimal doses one eight to one quarter of the calculated dose till desired plane of anaesthesia is attained. Intramuscular injections are administered in the pectorolis muscle. Leg muscle are avoided to prevent nerve damage. Xykzinc is administered in the dose range of 25 - 30 mg/kg IM and ketamine 5 mg/kg IM for small birds, 0.1 - 0.2 mg/g IM to parakeets and parrot, 0.02 - 0.2 mg/g IM to pigeon and chicken. Telazol is administered at the dose range of 5 - 10 mg/kg IM to parakeets, 7.5 - 15 mg/kg IM to pigeon and chicken and 2.5 - 10 mg/kg IM to parrot.

Minor surgical procedures upto 45 mt. sedation/anaesthesia birds weighing more than 250 g ketamine 10 mg/kg IM or less than 250 g 30 kg/kg IM can be administered. For intravenous administration one eighth one quarter of the IM dose is given initially and followed by required increment dose till the desired anaesthetic effect is reached.

Inhalation anaesthesia

Inhalation anaesthetics in birds can be administered through mask or through endotracheal tube, pediatric tube, feeding tube, polyethylene tube or urinary catheter can be used as endotracheal tubes in birds. Tidal volume in birds are smaller and hence the dead space has to be eliminated and precaution has to be taken to avoid kinking of tube.

Isoflurane

Isoflurane is the first choice of inhalation anaesthesia which has minimal effects on liver and kidney function.

Isoflurane is indicated at 3 - 5% and oxygen/h at 2 - 3 L. Maintenance depends on the size of bird 0.5 - 3% with oxygen 0.5 - 2.0 L/min.

Halothane

Induction with halothane is 3 - 4% and maintenance by 1.5 - 2% with 0.5% nitrous oxide. Halothane is contraindicated in systemic disease.
Monitoring and anaesthetic emergencies

Monitoring during anaesthesia include respiration depth, heart rate ECG or auscultation, cloacal temperature, level of narcosis and anaesthesia.

The following clinical signs indicate immediate intervention. Heart rate less than 120 beats per minute and or respiration less than 25 per minute in large bird or 30 per minute in smaller birds. Loss of all reflexes.

Anaesthetic administration is stopped or 100% oxygen in administered and cardiopulmonary resuscitation with digital pressure on the ventral carina 60 time/minute instituted. Doxapran 5 - 10 mg/kg IV or IM and fluids administered. Epinephrine can be administered to counteract cardiac arrest.

Recovery

The bird has to be wrapped in a towel or newspaper and thrashing or excitement avoided. It takes about 5 - 10 minutes recovery from isoflurane 15 - 20 mt. from halothane. 30 - 90 nts. from ketamine or xylazine water, food, tops should be removed from the recovery cage.
13. NERVE BLOCK TECHNIQUES IN LARGE AND SMALL ANIMALS

The desire and attempts to induce insensibility before embarking upon surgical operation have formed a part of mankind’s grouping towards civilisation. Nowadays, one can go so far as to prefer local analgesia to other forms of anaesthesia in many of the surgical instances since the general anaesthetic procedures involves sophisticated equipments, anaesthetic risks and economical constraints. Local or regional analgesia can be as the reversible loss of sensation over a limited body area with minimal effects on the rest of the body due to inhibition of the conduction of impulses by the peripheral nerves. Basically two techniques are commonly used in horses, cattle, sheep and goat and dogs. One technique involves application or injection of a local analgesic agent into the surgical site achieving local surface or infiltration analgesia. A second technique produces regional analgesia after perineural injection of major nerves (Nerve block analgesia) or epidural injection of the nerve roots as they emerge from the dura of the spinal cord (Epidural Analgesia). With a combination of physical restraint, mild sedation or tranquilization and local or regional analgesia many surgical procedures are performed in veterinary practice.

LOCAL ANALGESICS

There are many local analgesic drugs; they vary in potency, toxicity and cost. Three categories exist based essentially on relative duration of analgesic action. Procaine and 2-chlorprocaine have a relatively short duration of 30 to 60 minutes. Lidocaine (fast acting), Mepivacaine, and Hexylcaine represents agents of intermediary duration of 90 to 180 minutes. Tetracaine, Bupivacaine (fast and long acting) and etidocaine are agents with a long duration of analgesia of 180 to 240 min. The most commonly used local analgesic drugs in veterinary practice are amide linked drugs such as Lidocaine hydrochloride, Mepivacaine hydrochloride etc.

NERVE BLOCKS TECHNIQUE

Although there are a number of nerve blocks followed in animals only few nerve blocks and epidural analgesic procedures are practiced routinely in the following species of animals based on the clinical significance and feasibility.
1. **Auriculopalpebral Nerve Block**

The auriculopalpebral nerve is one of the terminal branches of the fascial division of the trigeminal nerve. It carries motor fibres to the orbicularis oculi muscles.

**Indication**: since this block prevents voluntary closure of the eyelids, it is useful for examination and treatment of the eye and temporary relief of eyelid spasms. In conjunction with topical analgesia it is useful for removal of foreign bodies from the cornea, worm from the eye and other minor ocular surgery.

**Site**: At the most dorsal point on the zygomatic arch.

**Technique**: A 2.5 cm 22-G needle is placed subfascially and 5 ml of 2% lidocaine hydrochloride injected in a fan-shaped manner.

2. **Infraorbital Nerve Block**

**Indications**: Analgesia of the upper lip and nose is induced by this block. It is indicated for extraction of teeth (as far as the first molar), trephination of maxillary sinus, operations on the roof of the nasal cavity and the skin almost to the medial canthus of the eye.

**Site**: At the infraorbital foramen which can be located about one half the distance and 2.5 cm dorsal to a line connecting the nasomaxillary notch and the rostral end of the zygomatic arch.

**Technique**: After displacing the flat levator labii superiors muscle dorsal, a 5 cm, 20-G, needle is inserted for a depth of up to 3.5 cm to make a perineural injection at the infraorbital foramen with 5 ml of 2% lidocaine hydrochloride.

3. **Mental Nerve Block**

**Indications**: Analgesia of the lower lip.

**Site**: At the mental foramen.
Technique: After displacing the tendon of the depressor labii inferioris muscle, the lateral border of the mental foramen is easily palpated and injected with 5 ml of 2.1 lidocaine with a 2.5 cm 20-G, needle or plantar ridge of the flexor tendon.

4. Caudal Epidural Analgesia

Indication: To desensitize the anus, rectum, vagina, bladder, urethra, tail and perineum.

Site: The first intercoccygeal Space.

Technique: The space is located by palpation as the first obvious midline depression caudal to the sacrum. Dorso-ventral manipulations of the tail allows the location of the 1st intercoccygeal space. To be confirmed, it is the first movable point caudal to the sacrum.

A 5 to 7.5 Cm, 18-G, spinal needle with stylet is inserted in the centre of the intercoccygeal space at an angle of about 30° to the horizontal plane until it strikes the floor of the vertebral canal. The needle is then withdrawn approximately 0.5 Cm and then the syringe loaded with 5 to 7 ml of 2% lignocaine hydrochloride is attached to the needle and injected slowly without affecting the motor fibres of the limb.

BOVINE

1. Retrobulbar Nerve Block

Indications: Enucleation, to Facilitate surgery and radiation therapy in cattle with squamous cell carcinoma of the cornea.

Contraindications: Deep Corneal Ulceration, Intracural Surgery.

Technique: The surgeon's Index finger is used to deflect the globe and protect it from the needle point. An 18 Gauge needle (7.5-12 Cm long) is inserted in the fornix of the conjunctiva caudal to the nictitans and dorsomedial to the operators finger. As the needle is inserted in the orbital apex, the medial wall of the bony orbit is felt. 10 to 15 ml of a 2% lidocaine hydrochloride solution is injected in small increments as the needle is advanced thereby pushing initial structures from the point.
2. Cornual Nerve Block

**Indications**: Dehorning, Debudding, Horn Fracture, Avulsions etc.

**Technique**: A 2.5 cm, 20 gauge needle is inserted through the skin approximately 2.5 cm anterior to the base of the horn and lateral to the palpable temporal ridge of the frontal bone. At this site, as the needle is inserted ventromedially close to the frontal bone, 5 to 10 ml of a 2% lidocaine hydrochloride solution injected subcutaneously. Needle penetration is from 1.0 cm in small cattle to 2.5 cm in large bulls.

3. Proximal Paravertebral Analgesia (Farquharson’s Technique)

**Indications**: Laparotomy, Rumenotomy, Caesarean, Enterotomy.

**Technique**: Nerves Blocked T11, L1, L2. Site for blocking T11 is 5 cm from the midline just cranial to the transverse process of L1 and for L1 just cranial to the transverse process of L2 and for L2 just cranial to the transverse process of L3.

The skin over the site is desensitized by injecting 2-3 ml of 2% lignocaine using a 2 cm long 15 G needle. Using this needle as a Cannula, a 15 cm 18 G needle is inserted down to contact the cranial edge of the transverse process of Lumbar vertebrae. The needle is then advanced about 1 cm to pass through the intertransverse ligament. About 10 ml of 2% lignocaine is injected to block the ventral branch of the respective nerve. The needle is withdrawn above the intertransverse ligament and another 5 ml of the solution injected at the level of the dorsal surface of the transverse process to block the dorsal branch.

4. Epidural Anaesthesia

**Indications**: Uterine prolapse, Amputation of tail, prevent straining, Urethrotomy, Surgical Procedures on external genitalia, Analgesia to perineal region and caudal thigh.

**Site**: Sacrococcygeal space first intercoccygeal space.

**Technique**: The site is located by elevating and lowering the tail and palpating the depression between the last sacral and first coccygeal or between first and second coccygeal vertebrae. A 10 cm long 18 G needle is inserted at a median plane at a right angle or at 10-15° to the vertical. Small quantity of the local anaesthetic solution is injected to make a dermal weal. The needle is then pushed down till it contacts the floor of the vertebral canal. 8-10 ml of 2% lignocaine is then injected. If the needle is in correct position there is practically no resistant felt during injection.
5. Pudendal Nerve Block

**Indications**: In female relief of straining during uterine prolapse and chronic vaginal prolapse. In male, penile analgesia and relaxation.

**Technique**: With cattle restrained in a standing position the lesser sciatic foramen is located by rectal palpation as a soft circumscribed depression in the sacrosciatic ligament. The internal pudendal nerve is found a fingers width dorsal to the pulsating pudendal artery present in the fossa. The skin over the ischiorectal fossa on both sides is disinfected and desensitized with 2-3 ml of 2% lidocaine hydrochloride solution. An 8.5 cm, 18 G spinal needle is passed for a distance of approximately 5 cm or until it contacts the internal pudendal nerve. 20-25 ml of a 2% lidocaine solution is injected around the nerve. The needle is then partially withdrawn and directed 2-3 cm caudodorsally where an additional 10 ml of the analgesic is deposited to desensitize the muscular branches and caudal rectal nerve.

NERVE BLOCKS IN GOATS AND SHEEP

Cornual Nerve Block in Goat

In goats, the horns are supplied by the cornual branches of the infra-trochlear nerve and the lacrimal nerve and both have to be blocked simultaneously. The cornual branch of the lacrimal nerve is blocked just behind the root of the supra-orbital process. With the needle near the caudal ridge of the orbit at a depth of 1.0 to 1.5 cm. The cornual branch of the infra-trochlear nerve is blocked at the dorso-medial margin of the orbit, as near to the margin as possible and at a depth of about 0.5 cm. In adult animals, 2 to 3 ml of 2% lignocaine is injected at each site.

Epidural Anesthesia in Sheep and Goat

Cranial epidural block can be used in sheep and goats to desensitize the abdominal region. The lumbosacral space can be used to induce cranial epidural block.

CANINES

1. Epidural Anaesthesia

**Indications**: Animals that are severely depressed are in shock or require immediate surgery of the rear quarters. Animals that are high risk, that are aged or in which the use of other analgesic or anesthetic agent is contra indicated.

**Site**: Lumbosacral epidural space.
Technique: The spinal needle should be placed perpendicular to the skin surface at the midline of the lumbosacral space. This can be palpated halfway between the dorso iliac wings and just caudal to dorsal spinous process of 7th lumbar vertebrae. This may be facilitated by prior infusion of the area with 2% lidocaine. The spinal needle in pushed slight ventrally in a slight cranial or caudal angle as needed. A distinct “POP” is usually felt when the needle is advanced through ligamentum flavum. Then 2% lidocaine of 1 ml/10 lb injected into the epidural space.

2. Retrobulbar Nerve Block

Indications: Surgical management of conditions of eyeball and membrana nictitans.

Site: Lateral canthus of eye.

Technique: The needle is inserted through lateral canthus of eye. 3-5 ml of anesthetic solution is injected to block the nerve. Use of special curved needle for retrobulbar anesthesia to reduce the risk of complications has been recommended.

3. Auriculo Palpabral Block

Indications: To relieve the spasm of eyelids following an eye injury, for management of surgical conditions of eyelids and eye ball. In conjunction with the retrobulbar block and for examination of the eye.

Site: Midpoint of the posterior third of zygomatic arch directly above its dorsal border.

Technique: The needle is directed towards the middle of the forehead as it is inserted subfascially over the mid point of the posterior third of zygomatic arch directly above its dorsal border. 5 ml of local anesthetic solution is injected.

4. Supra Orbital Nerve Block

Indications: Operations above the upper lid, suturing of wounds in the forehead and trephining of frontal sinus.

Site: Vertical line running upwards from the medial angle of the eye.

Technique: The foramen is felt as a small depression midway across the supra orbital process on a vertical line running upwards from the medial angle of eye. A 20 G 2-3 cm long needle is sued to deposit 5 ml of anesthetic solution.
NERVE BLOCK TECHNIQUES OF THE LIMBS

Palmar digital nerve block

1-2 ml of local anaesthetic agent is deposited over the nerve at the level of the lateral cartilage on the posterior aspect of the 2nd phalanx.

Digital nerve block

2-4 ml of local anaesthetic agent is deposited over the nerve at the proximal end of the 1st phalanx or at the base of the sesamoid bone just posterior to the digital artery and vein.

High Palmar nerve block

3-5 ml of anaesthetic agent is deposited just anterior to the deep digital flexor tendon and posterior to the suspensory ligament on both sides of the leg proximal to the anastomotic branch between the medial and lateral palmar nerves.

Ulnar Nerve Block

5-8 ml of anaesthetic agent is deposited in the muscular septum between the flexor corpi ulnaris and the ulnaris lateralis on the posterior aspect of the radius approximately a hands width above the level of the accessory corpal bone.

Tibial Nerve Block

10-12 ml of anaesthetic agent is deposited in the groove between the gastrocnemius tendon and the flexor hellicus longus on the medial aspect of the leg.

Peroneal Nerve Block

6-12 ml of local anaesthetic agent is deposited 1 inch below the facial covering of the groove between the long and lateral digital extensor on the cranialateral aspect of the leg approximately a hands width above the centre of the tarsal joint. As the needle is with drawn somewhat more solution was injected beneath the muscle fascia.
14. ELECTRONARCOSIS HYPOTHERMIA AND ACUPUNCTURE

ELECTRONARCOSIS

Electronarcosis is the electric stimulation of the brain and passage of electric current to produce anaesthesia. In the veterinary field clinical trials were conducted and may be of greatest use in situations where prolonged anaesthesia is required for experimental purpose. Most instruments deliver the current through needle electrodes applied to the head. Direct, pulsating direct, and alternating current have been used to produce electronarcosis. Alternating current of 700 cycles, 35-50 MA and approximately 40 volts has been employed. We can also use combined direct and alternating current, modified to produce a rectangular wave of 1.0 to 1.4 ms duration, with a frequency of 100 waves/sec. Continuous electrode contact is important to maintain electronarcosis. Individual variation among animals were observed and the current can be adjusted for each according to the response observed.

Electronarcosis is characterised by convulsions on induction unless a muscle relaxant is first administered. An exception to this is the method of employing direct current for induction and then both direct and alternating current. Profuse salivation can be counteracted by using atropine sulphate. Endotracheal intubation should always be performed. The EEG immediately following anaesthesia is decreased in amplitude, increased in frequency, but return to normal within 30 mts. Brain-lesions and skin burns from the electrodes have been reported occasionally.

It produces severe stress, increased plasma levels of hydroxycorticoides, epinephrine and norepinephrine. The blood pressure raises sharply and gradually falls to near normal levels. The clotting time, ESR, Hb, Hematocrit and DC donot differ. There is little effect on arterial oxygen partial pressure, CO₂ content and pH are lowered and blood glucose raises. In electronarcosis it is difficult to assess the depth of unconsciousness achieved and muscle relaxation varies from adequate to poor. This technique was recommended only for minor surgery.

HYPOTHERMIA

Hypothermia is a state in which the normal body temperature is reduced to subnormal level, thereby reducing the basal metabolic rate and oxygen demand of the body. The principle of hypothermia is being used in cardiac surgery and neuro surgery where the total body temperature is reduced upto 15°C to reduce the oxygen demand of the organ to minimum level
which helps in surgical manipulation of these organs under total circulatory arrest. Duration of circulatory arrest depend on level of cooling. Circulatory arrest helps in surgical correction of highly vascularized tissues in blood less field. Hypothermia is also being used in vascular surgery, excision of angiomas and liver surgery.

Depend on the level of cooling the hypothermia is named as moderate hypothermia (30°C - 25°C), deep hypothermia (25°C - 15°C) and profound hypothermia (less than 15°C).

Hypothermia in animal usually achieved by 4 methods. They are (1) Surface cooling (2) Intragastric cooling (3) Extracorporeal cooling and (4) Intraperitoneal cooling.

**Surface Cooling**

After anaesthetising the animal along with muscle relaxant, the hypothermia is achieved by immersing the animal in cold water or by covering the body with ice slush. Rewarming of the animal done by covering the body with blankets with provision to circulate hot water and by placing the animal on heated table. Disadvantage of this method are (1) Control over the achievement of level of hypothermia is difficult and (2) Time taken to achieve the level is longer.

**Intragastic method**

Here the animal is cooled by circulating cooled water through intragastric tube attached with balloon introduced into the stomach via mouth. The rewarming of the animal being done in same circulating warm water. It takes longest time to achieve even minimum level of cooling.

**Extracorporeal circulation**

In this method the venous blood is deviated to heart lung machine through canulae for oxygenation and cooling or warming and infused into the artery with help of roller pumps. Control over the level of hypothermia and rewarming is highly possible and the time taken to achieve hypothermia is less.

**Intraperitoneal cooling**

Here the animal is cooled by alternating infusion and drainage of cooled ringer's lactate solution into peritoneal cavity. In this method hypothermia level is reached quickly without any sophisticated equipment. This method recently being adopted for traumatized patient to reduce the oxygen demand of the vital organ during the critical period.
ACUPUNCTURE ANAESTHESIA

Introduction

The basic principle of acupuncture is the interaction of the yin-yong of the animal with the yin-yong of the universe. Yin is the negative force and yong is the positive force exist in all the living beings. The yin-yong theory separates organs in the body into the categories of Ts-ang and Fu. Ts-ang organs are yin and Fu organs are yong. An acupoint is a specifically designated location of the body surface. It is called the stimulating point.

ACUPUNCTURE TECHNIQUES AND EQUIPMENT

Methods of Stimulation of Acupuncture Points

Acupuncture therapy requires the simulation of one or more acupuncture points. There are many methods of producing this stimulation. A few are commonly used, some are rarely used, and some new ones are being investigated.

Needle

Needles are placed through the skin to the level of the acupuncture point. The needle is usually then manipulated to stimulate the point. This is the most commonly used technique and will be described in great detail.

Electromagnetic radiation

Various forms of light and sound have been used, such as ultra violet light, visible light focused by lens, laser beams and ultrasound. Electric fields and magnetic fields have also been used.

External pressure

Pressure is applied to the skin by several methods: (1) finger (2) teishin, which is a spring loaded, blunt metal probe and (3) granules, which are very small stainless steel balls applied to the skin with a small piece of tape.
Veterinary needle Acupuncture

Different types of acupuncture needles have traditionally been used to treat animals in China. The acupuncture needle, or hao chen, is widely used in both the East and West. Other needle types are of limited use; for example, the piercing jaundice needle may be replaced by surgical instruments.

Electroacupuncture

This technique involves the use of electricity to stimulate acupuncture points. Most commonly, the source of electricity is connected to needles in the acupuncture point. An alternative, used by some, is the application of electricity to the skin surface. Electroacupuncture is especially useful where one might want to stimulate several needles continuously for a long time, such as during the technique of acupuncture analgesia.

ACUPUNCTURE ANALGESIA

The use of acupuncture to produce analgesia for painful procedures such as dental work, surgery, and parturition has caught the public's fancy. Initially, there were very few details and very limited experimental information available in English; however, in the past few years much Chinese information has been translated and many neurophysiologic experiments have been done outside China. These studies have attempted to provide a better understanding of pain and analgesia, and the possible mechanisms of action of acupuncture analgesia.

THE USE OF ACUPUNCTURE ANALGESIA IN CHINA

The methods of acupuncture analgesia are currently used in China. The first method is the electrical stimulation of the San Yan Lo points. This method has been used in horses, mules, donkeys, cattle, and pigs. The second method is a special form of acupuncture analgesia and has been used only in donkeys and horses. It involves the stimulation of points in the ear. Electroacupuncture or manual stimulation may be used, depending on the skill of the practitioner, the number of points to be needled, and the time factor involved. In the stimulation of the San Yan Lo Points, local supplementary points are optional; in stimulation of the ear points, they are mandatory. Supplementary local points are points near the site of the operation that are in the same dermatome.
THE RELATIONSHIP BETWEEN THE SAN YAN LO POINTS AND THE NERVOUS SYSTEM

Analgesic effects can be obtained by simulating the nerve trunk anatomically related to a surgical area. The closer the needle is to the nerve trunk, the better the result. But results can be obtained by stimulating the nerve trunk directly. During surgical procedures, continuous stimulation is essential to maintain a level of stimulation to the cerebral cortex to inhibit or diminish the pain reaction caused by surgery. Analgesic effects can also be obtained by stimulating the nerve trunk anatomically unrelated to the surgical area.

The sites of insertion for analgesia are as significant as they are in acupuncture therapy for diseases. The choice of needling points along the nerve trunk depends on the easy accessibility and convenience of position. As far as the level of stimulation is concerned, the analgesic effect depends solely on the level of stimulation and is unrelated to induction time. No matter how long stimulation is sustained, no effect is produced if it has not reached the optimum level of intensity. In critically ill animals, adequately strong stimulation is usually applied, and surgery commences with a minimum of induction time. If the nerve trunk is overstimulated, the animal will become agitated, with tachycardia and rapid respiration. Different levels of stimulation are required at different acupuncture points. As a general rule, less stimulation is used if the point is located along a nerve trunk of plexus, and a large area of analgesia is produced; whereas at a point located in the area of muscle belly, a higher level of stimulation is required and the area of analgesia is small.
15. MONITORING OF ANAESTHETIZED PATIENTS

INTRODUCTION

Monitoring or Watching the animal during anaesthesia or surgery gives us the important parameters reflecting the Cardiovascular efficiency, Respiratory efficiency and the level of consciousness which are useful to improve the chances of the survival of the animal by indicating what treatment it needs, as well as its response to the treatment already given.

Monitoring can be done by the closed clinical observation of the patient and by using various monitoring devices.

The monitoring devices are electrical and electronic which

1. Should be extremely reliable and simple
2. Should indicate immediately any deviation from the normal
3. If the device develop a fault, it must "fail safe" and warn the anaesthetist.
4. Should cause no danger to the patient
5. Should be maintained well and compatible for use with other electrical equipment particularly diathermy.
6. In electrical apparatus, chance for ventricular fibrillation, which can be avoided by using isolation transformers.
7. Intra-arterial and intravenous lines for the measurement of pressure should be filled with 5% Dextrose and not saline because saline solutions are good conductors of electricity.

I. GENERAL MONITORING BY CLOSE CLINICAL OBSERVATION

The close observation is very essential monitor and should never neglected even when extensive measurement techniques are employed.

The most important monitor is the trained anaesthetists finger on a peripheral pulse because palpation of pulse allows knowledge of its rate, rhythm and volume as well as on indication of cardiac output and adequacy of the circulation to the region of the body where the pulse is being monitored. Difficulty in feeling the pulse in a major artery suggested that serious problems may be arising.
The colour of the mucous membrane also a very good guide to know the state of the patient.

Pink colour - indicates the adequate oxygenation of the blood. Bright or red-indicates the hypercapnia white colouration indicates anaemia, peripheral vasoconstriction or both of circulating fluid. Abnormal colouration also seen in dehydrated animals.

Cyanosis can only be seen where there is adequate blood flow to carry the deoxygenated haemoglobin to the mucous membranes. In practice it is rarely observed unless there is marked oxygen lack due to severe long disease or failure of oxygen supply to the breathing circuit. Causes may be respiratory obstruction or respiratory depression induced by overdose of anaesthetic drugs often result in concurrent circulatory failure.

Chest movements indicates the rate of breathing.

Capillary refill time is also an important observation (Time taken for the colour to return to skin or mucous membrane in an area which has been balanced by pressure).

II. MONITORING THE CIRCULATION

It aids the anaesthetist to detect the vital signs relating to the adequacy of the circulation. Numerous monitoring devices are available in the market.

1. Heart rate and rhythm

A number of factors control the heart rate. S.A. node is the normal pace maker is influenced by the impulses passing through the vagal. (Parasympathetic and sympathetic fibers).

Heart rate and rhythm can be measured by the following devices.

a) Simple bell stethoscope - kept at the region of the apex beat
b) Electronic Stethoscope
c) Oesophageal stethoscope - consists of the blind ended plastic or rubber tube with side holes over an area 1-3 cms from the blind end. This end is covered by a plastic or thin rubber sleeve to prevent fluid from entering the tube. This instrument is passed into the Oesophagus of the anaesthetized animal until the blind end lies over the heart and the open end is attached to an ordinary stethoscope head piece to a single ear piece. It is suitable for dogs and cats and is simplest most in expensive and effective monitors of the heart.
d) **Phonocardiogram** Electronic stethoscope by using a very sensitive microphone most of the heart sounds heard and can be recorded known as phonocardiogram. The conditions like heart murmurs, the movement of the left ventricle and some valve movements can be heard.

Phonocardiogram adds the capability of amplifying the sounds of the heart, by using this we can obtain timing relationship’s in the milliseconds between the various heart valves closing and opening.

 Intracardiac phonocardiogram used to determine the exact location of some problem in the heart.

Normal heart rate  
Dose 60-100/mt cats 100-200/mt.

2. **Pulse**

Pulse is the pressure change produced by ventricular ejection and propagated as a wave through the arterial tree to the periphery. The pulse can be palpated or can be monitored by special equipments, in the mandibular, carotid, Radial, Femoral or Coccygeal arteries.

A full bounding and regular pulse indicates good function of the cardiovascular system.

Fast, Weak, thready pulse may indicate cardiovascular collapse.

3. **Electrocardiogram**

The heart generates an electro chemical impulse that spreads out in the heart in such a fashion as to cause the cells to contract in a timely order and thus give the heart a pumping characteristic in the atria and the ventricles. This sequence is initiated by the sinusatrial node - a group of nerve cells. The result is a polarization and depolarization of the cells of the heart. Because it is electrical in nature and because the fluids of the body are conducive, this electro chemical action can be measured at the surface of the body. Unlike brain waves, very definite in pattern so that can be measured and very accurate evaluation of the heart’s condition is possible.

S.A.node sets the rate at which the heart beats with an unimpulse the atria contract via the action potential of the nerve cells of the atria. The pulse is also carried by nerves down to another node is Atrio ventricular node or A.V.node. Which spreads the pulse down between the
left and right ventricles via the Purkinje fibres so that the ventricles contract. This sequence is well timed so that the atria depolarize first (making the atria contract and sending blood to the ventricles) and the ventricles depolarize next (making the ventricles contract and sending blood to the lungs and the body). When ventricles are depolarizing the auricles are repolarizing. This sequential contraction and relaxation is possible because of nerve cells that carry the unimpulse at the right speed for the sequence to be co-ordinated the heart thereby acts like a pump.

When the above gets upset, the S.A. node does not send out a pulse, the heart loses this co-ordination and is said to be in a fibrillating condition.

The electrical action of the heart can be measured on the surface of the body, because the electrical currents from the heart spreads through the entire body. By applying electrodes to various positions on the body and connecting these electrodes to an electrocardiographic apparatus the electrocardiograph is recorded.

The electrodes normally two, one is fixed on the brisket and another one is fixed between the xiphisternum and the umbilicus.

The electrodes or leads like needle electrodes may be inserted subcutaneously or intramuscularly. Crocodile clips also equally satisfactory. To get a good contact with the skin the jelly can be used with the electrodes should be renewed during the course of a long operation.

Electrodes should be silver plated to eliminate the polarization and electrochemical currents.

The electrocardiograph consists of the waves P, Q, R, S, T, and U.

P Wave is the deflection of atrial depolarization
Q Wave is the initial negative deflection of ventricular depolarization.
R Wave is the first positive deflection of ventricular depolarization.
S Wave is the negative deflection of ventricular depolarization
T Wave is the ventricular repolarisation
U Wave is due to the failure of the restoration of the normal membrane resting potential at completion of repolarisation.
P-R interval measures the atrio ventricular conduction time
QRS interval measures the total ventricular depolarization time.
QT interval measures the duration of electrical systole.

By this electrocardiograph changes in rate and rhythm of the heart are most easily recognised, which increases the anaesthetist ability.
The rate below the lower limit is termed as Bradycardia and above the upper limit is tachycardia. The normal rhythm is accelerated during inspiration and slowed during expiration known as sinus arrhythmia.

Can be abolished by the vagolytic agents like atropine and general anaesthetics.

Atrial fibrillation is characterized by the absence of discrete P wave by irregular undulations in the base line.

Ventricular fibrillation is characterized by the QRS complex of high amplitude.

4. **Measurement of arterial blood pressure**

The pressure in the arterial tree is a product of cardiac output and total peripheral resistance.

Cardiac output = Heart rate x Stroke Volume  
Blood pressure = Peripheral resistance x cardiac output  
The blood pressure can be measured either by Direct or indirect methods.

A. **Indirect method**

Is the method to measure the absolute arterial blood pressure without inserting needles or tubes, by the use of the acoustical stethoscope and an inflatable cuff, known as Korotokoff method.

1. **Korotokoff method**

In this the stethoscope is placed over a limb artery distal to the occlusion by a inflatable cuff. Inflated to a pressure greater than the systolic pressure. Then slowly deflated until the first Korotokoff sound is heard at this point the pressure is the systolic pressure and on further deflation the Korotokoff sound muffles or disappear and at this point the cuff pressure is taken as Diastolic pressure.

Normally the systolic and diastolic pressure is about 120 mm and 80mm of Hg respectively.
2. **New castle sphygmomanometer with xylol pulse detector**

   Used in dogs and other animals consists of an occluding cuff connected to a mercury manometer and distal pulse sensing cuff attached to the xylol indicator.

3. **Plethysmographic technique**

   In this two types.

   a) **Photoelectric plethysmography**

   Consists of photoelectric cell and a light source. When attached to a patient the pulsating blood will continually increase and decrease the amount of light reaching the photo cell. This in turn is converted to a varying voltage by a bridge network and displayed on an oscilloscope.

   b) **Finger plethysmography**

   In this technique the change in the finger size with blood flow is utilized.

4. **Doppler shift method**

   Ultrasonic sphygmomanometers for indirect measurement of arterial blood pressure is more accurate than other non-invasive techniques.

B. **Direct method**

   The arteries selected for catheterization are saphenous artery and femoral artery in dog and cats.

   The cannulation of blood vessel is done by using a plastic cannula over the needle type. After reaching the lumen of the blood vessel the cannula alone is kept in the vessel and the needle is withdrawn. The cannula is connected to a stopcock and the system is flashed heparin saline solution (2 units/ml). The cannula is fixed in position and is connected to a pressure transducer via a length of manometer connective tube.

5. **Measuring central venous pressure**

   The heart takes blood from a low pressure venous reservoir and pumps it into a high resistance arterial circuit. Nearly 70-80% of the total blood volume is seen in the venous side.
under normal circumstances. Determination of CVP provides valuable indication about the
efficiency of cardiac function in relation to circulating blood.

In practice simplest method is to cannulate the jugular vein or cephalic vein and the tip
of the cannula is advanced still it reaches the anterior venacava. Cannulation is achieved by
percutaneous needle puncture technique. When the catheter reaches the anterior vena cava it is
connected to a conventional infusion set by a three way stop cock.

A tube attached to the otherside of the stopcock will acts as water manometer. The
catheter is flushed with heparin in saline solution by adjusting the stopcock. The manometer tube
is filled with 0.9% saline solution to a level at least 20 cm above the animals chest level. The tap
is turned so that the full manometer tube is in direct connection with the catheter. The saline level
will fall slowly with characteristic oscillation in time with respiratory movements. the zero
reference point is taken in level with sternal manubrium. The water column comes to rest when
the hydrostatic pressure in the tube is balancing the pressure in great veins.

In normal subjects the CVP will be between 3 and 7.5 cm H20. A high CVP is associated
with either over transfusion or reduced cardiac output. Allow CVP reflects either low blood
volume or a high cardiac output. CVP informs the anaesthetist regarding the ability of the right
heart to tolerate and eject the fluid load.

The complications of CVP measurements are thrombophlebitis infection, bleeding arterial
puncture, pneumothorax. Infusion of fluids into the chest, Air embolus, catheter embolus.

6. **Pulmonary wedge pressure**

This measurement provides a good index of functional competence of the left side of the
heart. If the left atrial pressure is kept below 1.20 mm Hg, pulmonary edema can be prevented
during anaesthesia. The subclavian vein is cannulated for the measurement.

7. **Cardiac output**

Dye or thermal dilution are used for accurate measurement. Indocyanine green is used
as dye. Cold saline is used as indicator in thermal dilution technique.

Another method is with a oesophageal ultrasound probe and aortic venography.
III. MONITORING RESPIRATION

Respiration can be measured in several ways by

a) determining the oxygen level in the blood.
b) recording the chest movement.
c) measuring the lung motion.
d) measuring change in lung resistance
e) measuring lung tidal volume the amount of air inhaled.
f) displaying the shape of the curve generated by the lungs expanding and contracting.

1. Respiratory rate and pattern

The pattern is evaluated by counting the breaths/mt and at the sometime observing the quality of breathing whether it is shallow or deep, regular or irregular. The rebreathing bag will help in counting the respiration.

Rate monitors and apnoea alarms use a thermistor placed in the air way to detect the temperature differences between the inspired and exhaled gases. The signal derived from the thermistor is used to drive a digital rate meter to make a noise varies in intensity or pitch in time with the animals breathing or to sound an alarm if a constant gas temperature is detected.

Oesophageal stethoscope is also useful in monitoring for the presence of respiration its character and the degree if any of obstruction.

Electronically a new technique known as impedance pneumography provides more accurate data because it measures the change in resistance of the lungs as a person breaths. The principle upon which it works, is the resistance of air and the change in the resistance as a result of breathing. The parameters moniterable are

a. Respiration rate
b. Apnoea
c. Accurate wave form of the breathing pattern
d. A relative measure of tidal volume.
2. **Tidal and minute volumes**

   a) Can be measured in small animals by introducing weight's respirometer into the breathing circuit.

   b) Ventimeter - useful in breathing circuit for tidal monitoring.

   c) Pneumatachography:
   
   A method for determining the rate of air flowing into the lungs and by integrating this rate determining the tidal volume rate is called pneumatachography.

   In this technique uses a differential pressure transducer a device which has an electrical output only when a changing pressure is sensed.

   By placing a mask over a patients nose and mouth which allows normal breathing. Place a fine mesh screen in a tube leading from the mask to the surrounding air, a slight pressure differential will develop in the tube on either side of the screen. This pressure differential has been found to be proportional to the air flow velocity can be detected with differential pressure transducer. By integrating this air flow rate, tidal volume can be determined.

   d) Spirometer
   
   For patients not requiring constant monitoring but for measurement of tidal volume is desired, spirometer is used. The resultant tracing is known as spirogram.

3. **Monitoring of arterial blood gas tensions**

   The most effective way of monitoring respiratory efficiency is to measure the levels of oxygen and CO₂ in the arterial blood and blood gas measurements also give the anaesthetist valuable information about the acid-lease status of the animal.

   The blood should be collected in a plastic disposable or glass syringe in slowly over several respiratory cycles. The dead space of the hub of the syringe should be filled with heparin solution, before collection of the sample and any gas bubbles in the syringe afterwards should be expelled before sealing the hub with a cap. After inverting the syringe several times to mix the blood with heparin it should be kept immersed in a mixture of ice and water until analysis is performed. Analysis should be undertaken as soon as possible.
4. **Infra-red gas analysis**

In animals with healthy lungs, the level of CO₂ contained in the air which is last expired (end tidal air) approximates to that of the arterial blood. Infra-red CO₂ analysers can be used to sample gas in the endotracheal tube and give continuous record of CO₂ levels at this site throughout the respiratory cycle.

Continuous measurement of CO₂ concentrations in this way is a useful monitor for pulmonary embolism and may warn of changes in cardiac output.

**IV. MONITORING BODY TEMPERATURE**

Temperature is not commonly thought of as a clinical parameter it is a regulatory process that uses chemistry of the body to achieve regulation. The regulation is by the hypothalamus in the brain.

The regulatory process is remarkably sensitive normally keeping the body temperature as constant.

Several openings in the body make the internal body temperature, which reflects any changes occurring inside the body as a result of infection or injury very easy to measure. The openings are

1. Oral - Skin below the tongue in human
2. Rectal - area just inside the rectum (anus) in animals.

Several techniques are used to measure temperature familiar one is the mercury thermometer.

For continuous monitoring electronic thermometer is used.

**V. MONITORING OF URINARY OUTPUT**

The urinary output depends on the renal blood flow which in turn depends on cardiac output and circulating blood volume and thus it is a relatively sensitive indicator of the circulatory state.
Catheterization of the urinary bladder is a simple operation in most domestic animals and the urine may be drained to a plastic bag for collection and subsequent measurement. Repeated catheterization not only disturbs sick or badly injured animals but also multiplies the risk of introducing infection into the bladder and traumatization of the whether so that either self-retaining catheters should be used or once inserted the catheter should be fixed in place with a suture or adhesive plaster. In restless animals where continuous drainage is difficult, the open end of the indwelling catheter may be clamped the clamp bring released every hour to drain the accumulated urine.
16. VENTILATION IN LARGE AND SMALL ANIMALS

One of the most opt practice of providing safe general anaesthesia is the maintenance of normal ventilation. Normal ventilation is defined as the ability to maintain arterial CO₂ levels within normal limits (35-40 mm Hg). Generally respiratory efforts can be visualised by observing the patient’s chest and abdominal wall movement. Although these movements may be regular and give the appearance of satisfactory gas exchange, they do not ensure adequate movement of air in and out of the lungs. Adequate gas exchange can be provided by inflating the lungs to a predetermined pressure or volume by manually squeezing a rebreathing bag on an anaesthetic machine or utilising a mechanical ventilatory assist device. High frequency ventilation is unique technique for ventilating patients. This technique utilises the principle that diffusion is the primary means by which fresh gases are delivered to peripheral airways gas exchange sites.

GENERAL CONSIDERATION

The following items should be taken care for effective application like

a. Proper use of Artificial ventilation
b. Thorough knowledge of cardiopulmonary physiology and blood gas interpretation.
c. Practicing in patients those who are not breathing adequately.
d. Need of blood gas analysis.

Respiratory Inadequacy: (In General)

Respiratory inadequacy (Hypoventilation) results due to many factors as follows:

a. Respiratory centre depression due to

<table>
<thead>
<tr>
<th>Drug</th>
<th>Metabolic</th>
<th>Physical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anaesthetic, Drug toxicities, Neuromuscular blocking agents.</td>
<td>Acidosis, Coma and Toxins</td>
<td>Trauma-nerve (edema), chest, Head (increased intracranial pressure) and nerve severance.</td>
</tr>
</tbody>
</table>
b. Inability to expand thorax (adequately) caused by

Pain, chest trauma, thoracic surgery, abdominal distension, muscle weakness, obesity, bony deformities of the chest wall and positioning.

(impedement due to viscera weight and abdominal compression).

c. Inability to adequately expand the lungs due to

Pneumothorax pleural fluid, diaphragmatic hernia, thoracic surgery neoplasia, pneumonia.

d. Acute Cardiopulmonary arrest

e. Pulmonary edema

Respiratory inadequacy in Anaesthesia and Ventilation

a. Provision of ventilation in cases subjected for anaesthesia since anaesthetic agents are respiratory depressants.

b. Cases with different condition enlisted earlier when subjected for Anaesthesia.

c. During thoracic surgery, neuromuscular blocking drugs (Horse), prolonged anaesthesia, trauma, CNS trauma and overdose of drug.

d. Failures in Anaesthetic machine and procedure due to failure of operation, improper intubation improper inflation. Improper oxygen concentration. Type of anaesthetic agents (N₂O).

Physiological Parameter

To maintain normal ventilation and possible leakage can be ascertained by following the normal physiological parameter. The following range is essential to maintain normal ventilations.
<table>
<thead>
<tr>
<th></th>
<th><strong>Small Animals</strong></th>
<th><strong>Large Animals</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Respiratory rate</td>
<td>8-12/ml</td>
<td>10-14 breath -H/Cow</td>
</tr>
<tr>
<td>Tidal volume</td>
<td>10-12m/Kg</td>
<td>6-10 ml/kg</td>
</tr>
<tr>
<td></td>
<td>(15)</td>
<td>(10)</td>
</tr>
<tr>
<td>Peak airway pressure</td>
<td>15-20 Cm H₂O</td>
<td>20-30 cm H₂O</td>
</tr>
<tr>
<td>Inspiratory Period</td>
<td>1.0 to 1.5 Seconds</td>
<td>1.5 to 3.0n Seconds</td>
</tr>
<tr>
<td>Expiratory Period</td>
<td>3.0 Seconds</td>
<td></td>
</tr>
<tr>
<td>Inspiration expiration ratio</td>
<td>1:2, 1:3</td>
<td>1:1, 1:2</td>
</tr>
<tr>
<td>Evaluation of ventilatory process</td>
<td>POCO₂ &lt; 40 mg/kg</td>
<td></td>
</tr>
<tr>
<td>Normal chest movements</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Physiological Considerations**

During spontaneous ventilation, the portion of the lung in closet contact with moving surface (Peripheral) receive the greater volume of inspired gases, in contrast during artificial ventilation, peripheral segments remain relatively hypoventilated. During spontaneous, ventilation the sub atmospheric pressure is made more negative during inspiration by downward movement of the diaphragm, augments venous return. But during artificial ventilations, the pressure in the treache and lung is transmitted to the thorax cavity thus impeding venous return and decreasing cardiac output results in decrease arterial pressure and ventilation perfusion abnormalities.

(Normal Inspiration → downward movements of diaphragm → More venous return → Artificial respirators reduced venous return → reduced cardiac output → decreased artery pressure → ventilation perfusion abnormalities).

**Terminology of Mechanical Ventilation**

Several abbreviations are used in the Medical literature to describe various types of ventilation.
1. **Intermittent Positive Pressure Ventilation (IPPV) (IPPB)**

   Positive pressure is maintained only during inspiration (airway pressure is maintained above ambient pressure)

   a. **Control mode ventilation (CPPV-CMV)**: is a form of IPPV in which a ventilator delivers a preset tidal volume of a preset frequency.

   b. **Assist control mode ventilation (AMV)**: provides a preset tidal volume and preset frequency of ventilation from the ventilator in response to patients initiate attempts to inspire and fails to initiate breath respectively.

2. **Continuous Positive Airway Pressure (CPAP)**

   Airway pressure in maintained above ambient pressure during spontaneous breathing (continuous).

3. **Positive end - Expiratory Pressure (PEEP)**

   Airway pressures at end expiration is maintained above ambient pressure used to open small airways following lung trauma and pulmonary edema.

4. **Zero end - Expiratory Pressure (ZEEP)**

   Airway pressure at end expiration is maintained normal to assist pressure expiration.

5. **Negative end - Expiratory Pressure (NEEP)**

   Airway pressure at end expiration is maintained negative pressure to assist and hasten expiration.

6. **Intermittent Mandatory Ventilators (IMP)**

   Method of ventilation is used for ventilatory support and for weaning of patients from ventilators by inserting mechanical breath.

7. **Assisted and Controlled Ventilators**

   Assisted ventilation is performed by manual compression of breathing bag or initiation by the patient when creates negative pressure during an attempt to breath.
Controlled ventilation in which inspiration is initiated by the ventilator with preset frequency, tidal volume, minute volume.

**Classification of Ventilators**

**a. Volume cycle ventilators**

A gas/mixture is delivered in a preset volume (Piston or bellows type) or preset basic flow rate of gas for specific of time (Time flow type).

Advantage: Delivers known tidal volume, constant volume despite shifting of the lungs during anaesthesia, availability of blow off safety value to prevent the development of extremely high pressure, simple machine.

Disadvantage: High air pressure, do not compensate for small leaks.

**b. Pressure cycled ventilators**

A gas/mixture is delivered by a Ventilatory assist device during the respiratory phase until the system reaches preset pressure.

Advantages: High safety factor - high pressure will not develop. Small leaks are compensated, large leaks cause prolongation of inspiratory time.

Disadvantages: Volume delivered is variable due to long compliance, airway resistance, number of functional alveoli, pressure with out thorax, difficulty in measuring the tidal volume. If it is not with bellows pressure, may need to be increased during a procedure.

**c. Tank Ventilators**

Delivers a negative pressure to the body.

Advantages: Improves hemodynamic by producing negative pressure in the chest during inspiration. Minimal reduction in lung compliance.

Disadvantages: Limited access to the patient, Controlled environmental chamber.

**Ventilators Commonly used in Veterinary Medicine**

The following Ventilators enlisted in the table are commonly used in small and large animals in Veterinary practice.
Guidelines for use

The ventilators has to be set for tidal volume (10 and 20 ml/kg), inspiratory time (1 to 15 seconds for small and less than 3 seconds for large animals), inspiratory pressure (12 and 30 cm of H₂O, espiratory rate (8-12 breath/mt) in small and (6-10 breath/mt) in large animals and I.E. ratio 1:2 or less.

Hazards associated with the use of Ventilators

General hazaards associates with ventilators include Hypoventilation due to power failure, dysfunction of the ventilator, cycling failure, inadequate design for the patient, heat as driving gas, loss of breathing system gas, in correct settings and obstructions to flow. Hyperventilation, exceeding airway pressure, negative pressure during expiration.

Clinical signs of Hypoventilation

This is done by visual inspection and assessment of arterial blood gas. Sternous breathing, Cyanosis, abnormal position of the animal, sternal recumbency, abduction of the fore limbs, extension of the neck and head and Hypercarbia are the cardial signs of Hypoventilation.

Corrective Measures

1. Suitable care and removal of primary cause
2. Control and assist breathing
3. Use of respiratory stimulants - Doxapram 0.05-0.2 mg/lb, Nikethamide 2-4 mg/lb
4. Intravenous administration of sodium bicarbonate to act on acidosis.
5. Hyper extension of the neck and tongue.
8. Intravenous fluid therapy.
10. Wide opening of mouth.
<table>
<thead>
<tr>
<th>Ventilator</th>
<th>Power Source</th>
<th>Drive Mechanism</th>
<th>Cycling Mechanism</th>
<th>Type of Ventilation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drager SAV (SA)</td>
<td>Pneumatic</td>
<td>Pneumatic and Electronic</td>
<td>Time-Fluidic</td>
<td>Control</td>
</tr>
<tr>
<td>Hallowell EMC 2000 (SA)</td>
<td>Pneumatic and Electronic</td>
<td>Pneumatic and Electronic</td>
<td>Time-Fluidic</td>
<td>Control</td>
</tr>
<tr>
<td>Mallard 2400 (SA)</td>
<td>Pneumatic</td>
<td>Pneumatic and Electronic</td>
<td>Time-Fluidic</td>
<td>Control</td>
</tr>
<tr>
<td>Metronic (Ohio)-SA</td>
<td>Pneumatic</td>
<td>Pneumatic and Electronic</td>
<td>Time-Fluidic</td>
<td>Control</td>
</tr>
<tr>
<td>Olimb 7000 (SA)</td>
<td>Pneumatic</td>
<td>Pneumatic and Electronic</td>
<td>Time-Fluidic</td>
<td>Control</td>
</tr>
<tr>
<td>ADS 1000 (SA)</td>
<td>Pneumatic</td>
<td>Pneumatic and Electronic</td>
<td>Time-Fluidic</td>
<td>Control</td>
</tr>
<tr>
<td>SAV 75 (SA)</td>
<td>Pneumatic</td>
<td>Pneumatic and Electronic</td>
<td>Time-Fluidic</td>
<td>Control</td>
</tr>
<tr>
<td>Drager AV (LA)</td>
<td>Pneumatic</td>
<td>Pneumatic and Electronic</td>
<td>Time-Fluidic</td>
<td>Control</td>
</tr>
<tr>
<td>Nillvext E</td>
<td>Pneumatic</td>
<td>Pneumatic and Electronic</td>
<td>Time-Fluidic</td>
<td>Control</td>
</tr>
<tr>
<td>LAIV 2000 (LA)</td>
<td>Pneumatic</td>
<td>Pneumatic and Electronic</td>
<td>Time-Fluidic</td>
<td>Control</td>
</tr>
<tr>
<td>Mallard 2800 (LA)</td>
<td>Pneumatic</td>
<td>Pneumatic and Electronic</td>
<td>Time-Fluidic</td>
<td>Control</td>
</tr>
</tbody>
</table>

L.A. Large animal; S.A. Small animal. Small animal indicates the primary use of ventilator. Bellow-described in reference to the direction of movement during expiration.
17. ANAESTHETIC EMERGENCIES AND MANAGEMENT

Anaesthetics and ancillary drugs induce alterations in the homeostasis in healthy animals as well as on surgical patients whose vital functions are compromised. The complications or emergencies during anaesthesia and surgery are due to the underlying diseases process, use of anaesthetics and ancillary drugs, duration of surgery, manipulation of the organs and their reflexes on the vital functions and body positions in preconditioned patients.

SUPPORTIVE THERAPY

Most of the anaesthetic emergencies can be prevented by suitable supportive therapy which includes proper body positioning, fluid administration, mechanical ventilation, cardiovascular support and by providing circulating warm water heating blankets under good monitoring techniques.

PATIENT POSITIONING

In ruminants and horses dorsal recumbency makes the whole surgical procedure under general anaesthesia more stressful because of the ventilation-perfusion mismatch and improper haemodynamics. The stress during surgery under anaesthesia is less stressful in horses provided the horses are positioned

1. On smooth flat and padded surface.
2. Place a pad beneath the patients head to protect the masseter muscle, eye and facial nerve.
3. Placing an automobile inner tube beneath the elbow and shoulder of the front leg.
4. Preventing extreme extension of patients neck to avoid tension over the facial arteries and to prevent the laryngeal hemiplegia and airway obstruction during recovery.
5. Provision of water mattresses are the most ideal.

In ruminants better haemodynamics and pulmonary functions were observed during right lateral recumbency. Dorsal recumbency is more stressful as compared with left lateral recumbency.
FLUID ADMINISTRATION

All the anaesthetised animals should be maintained with a lifeline by using indwelling catheters or by the use of cut-down cannulas. The lifeline is maintained to provide fluids for the animal's maintenance requirements, to maintain adequate renal perfusion and to administer emergency drugs during anaesthesia and surgery.

During anaesthesia Ringer's lactate, Normal saline, 5% dextrose, sodium bicarbonates and hypertonic saline administered as supportive therapy.

1. During prolonged anaesthesia bicarbonate solutions can be administered to prevent metabolic acidemia.
2. Anorectic neonatal foal may not have adequate amount of glycogen. Solutions containing 5% dextrose must be administered to them.
3. Hypertonic saline (5-7%) can be used as a resuscitative agent in animals under shock.
4. The rate of fluid administration advocated are 4.4 - 6.6 ml/Kg/hour to maintain the patients hydration and circulation blood volume.
5. 11.00 ml/Kg/hour to prevent shock and upto 12 litres/hour in critical cases and in severe cases.
6. Considerable haemorrhage during surgery can be managed by whole blood transfusion or infusions with 3.00 ml of isotonic fluid/1 ml of haemorrhage.

VENTILATORY SUPPORT

Air-way patency must be maintained by endotracheal intubation for artificial ventilation at times of emergencies. The guidelines for using mechanical ventilators are as follows.

| Volume     | 20 ml/Kg body weight |
| Pressure   | 50 to 30 cm H2O |
| Rate       | 8-14 breaths/min in dogs |
|            | 10-14 breaths/min in cats |
|            | 6-10 breaths/min in Horses |
|            | 6-10 breaths/min in Cows |
|            | 8-12 breaths/min in Sheep and Goats |
|            | 8-12 breaths/min in Pigs |
| Inspiratory : Expiratory ratio | 1 : 2 or 1.3 |
EMERGENCY SUPPORT

Respiratory Emergencies

In the event respiratory emergencies the first thing to do is to stop the administration of anaesthetic agents and ventilate manually with oxygen. This can be achieved by "bagging". The rebreathing bag must be emptied and refilled with oxygen. Manual or mechanical ventilation should continue at 1-2 breaths per minute until spontaneous ventilation resumes. Proper drug therapy should be instituted at this time.

CARDIAC EMERGENCIES

The depth of anaesthesia is decreased with ventilation hypotension with a mean arterial pressure less than 75 mm Hg in adult horses, sheep, goats and swine, less than 65 mm Hg in foals and less than 90 mm Hg in cattle indicate proper drug therapy.

EMERGENCY MEDICATIONS

<table>
<thead>
<tr>
<th>Drug</th>
<th>Dose</th>
<th>Indications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium chloride (inotrope)</td>
<td>1.0 ml/9.0 Kg I/V</td>
<td>To correct mild to moderate hypotension</td>
</tr>
<tr>
<td>Calcium borogluconate (inotrope)</td>
<td>0.55 - 1.10 ml/Kg/hr</td>
<td>To correct hypotension</td>
</tr>
<tr>
<td>Dobutamine (Sympathomimetic amine)</td>
<td>0.5 - 2.0 µg/Kg/min</td>
<td>To correct moderate to severe hypotension</td>
</tr>
<tr>
<td>Dopamine (Sympathomimetic amine)</td>
<td>1.0 - 5.0 µg/Kg/min</td>
<td>To correct moderate to severe hypotension</td>
</tr>
<tr>
<td>Ephedrine (Stimulates alpha 1 predominantly)</td>
<td>given as a bolus 0.022 - 0.066 mg/Kg I/V</td>
<td>To correct mild to moderate hypotension</td>
</tr>
<tr>
<td>Isoproterenol (Sympathomimetic amine - strong Beta-2 effects)</td>
<td>1. 0.2 - 0.4 mg in a liter of lactated ringers or saline 2. 0.2 mg in 250 ml of saline or lactated ringers</td>
<td>1. To increase cardiac output. 2. To revive cardiac arrest. (Due to B-2 action it causes peripheral vasodilation hence adequate fluid volume must be maintained)</td>
</tr>
<tr>
<td>Epinephrine (Stimulates alpha 1,2 and beta 1 and 2 adrenergic receptor)</td>
<td>5.0 ml of a 1:1000 solution I/V or intra cardially</td>
<td>To revive cardiac arrest.</td>
</tr>
<tr>
<td>Drug</td>
<td>Dose</td>
<td>Indication</td>
</tr>
<tr>
<td>---------------------------</td>
<td>-------------------------------</td>
<td>-------------------------------------------------</td>
</tr>
<tr>
<td>Doxapram</td>
<td>0.55 mg/Kg I/V</td>
<td>To reverse alpha adrenergic agonist.</td>
</tr>
<tr>
<td>(Primarily respiratory stimulants)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sodium bicarbonate</td>
<td>2.2 mEq/Kg</td>
<td>To correct metabolic acidosis.</td>
</tr>
<tr>
<td>(Buffer aids in reversing metabolic acidosis)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corticosteroids</td>
<td></td>
<td>In the treatment of shock and malignant hypothermia (Prednisolone is superior to Dexamethasone)</td>
</tr>
<tr>
<td>(to maintain vasomotor response of vessels)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Prednisolone sodium succinate 30-60 mg/Kg/8 hr</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Methyl prednisolone sodium succinate 15-60 mg/Kg/8 hr</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Dexamethasone sodium phosphate 2-6 mg/Kg/8 hr</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lidocaine</td>
<td>0.5 - 2.0 mg/Kg I/V to the maximum of 2.0 mg/Kg over a period of 15 mts.</td>
<td>To correct premature ventricular contraction</td>
</tr>
</tbody>
</table>