3.0 MATERIALS AND METHODS

The objective of the present study was to evaluate the efficacy of modified spinal stapling and tension band wiring with or without hemilaminectomy and non-surgical treatment for traumatic posterior paralysis in dogs.

3.1 Occurrence

The occurrence of traumatic posterior paralysis in different breeds, age groups and sex of dogs were recorded.

3.2 Source of animals

The study was conducted on 18 dogs of different age, sex, breed and bodyweight brought to the College Hospital with paraplegia of traumatic origin. The dogs with traumatic injury of the spinal cord of external origin viz., automobile accidents, falling from heights, attack by humans or animals and blunt objects falling on them, and traumatic injury of internal origin subsequent to intervertebral disc extrusions or protrusions were included in the study.

All the dogs presented with traumatic posterior paralysis were subjected to detailed evaluation as hereunder and they were allotted to the appropriate treatment groups.

3.3 Pre-treatment evaluation

3.3.1 Case history

History and observations narrated by the owner were recorded to determine the possibility of involvement of the spinal cord.

3.3.2 Physical examination

The dogs were placed on the examination table and their vertebral column and bones of the limbs and pelvis were palpated to detect abnormalities. The spinal columns were palpated from caudal to cranial
direction to detect any gross abnormality of the vertebrae and to detect pain response from the animal.

### 3.3.3 Clinical examination

All the dogs were subjected to a detailed clinical examination. Temperature (°F), heart rate (beats/min) and respiratory rate (breaths/min) were recorded.

Routine clinical examination was performed to detect the presence of other complications like internal haemorrhage, pneumothorax etc. The urinary bladder function was assessed by palpating the bladder through the abdominal wall. Cystoplegic dogs were graded as having lower motor neuron bladder or upper motor neuron bladder based on whether urine was freely relieved or not when the bladder was pressed through the abdominal wall. Presence of voluntary urination with occasional dribbling or normal urination was also noted.

### 3.3.4 Neurological examination

Following initial assessment of the dogs, detailed neurological examination was performed and the following parameters were recorded.

**Attitude, posture and gait:** The general attitudes of the dogs were recorded as alert, depressed or stuporous. Posture assumed by the dogs when left on the floor was noted and recorded as recumbent, sitting, or standing with or without help. The dogs were allowed to move on their own to detect abnormalities in gait such as dragging of hind quarters, ataxia, occasional ataxia or whether they had a normal gait. Movements were avoided if a gross abnormality of the vertebral column was visible on physical examination.

**Locomotor status:** The locomotor status of the dogs was evaluated based on the observations of the owner and after attempting to make them to move on the floor. However, care was taken to avoid excessive movements of the vertebral column to prevent further damage to the
spinal cord. When a gross abnormality of the vertebral column could be detected on presentation, no attempt was made to make the animal move about to prevent aggravation of the spinal cord injury. Based on the observations, the dogs were classified as paraparetic, tetraparetic, paraplegic, tetraplegic or hemiplegic. Only paraplegic dogs were selected for the present study.

**Conscious proprioception:** The dogs were lifted and their paws turned backwards to make the dorsal surface of the paws to touch the ground (Fig. 10). The ability of the animal to return the paws to the normal position (conscious proprioception) was assessed and recorded as present or absent.

**Deep pain sensation:** Deep pain sensation was assessed by pinching the toes with an artery forceps (Fig. 11). Based on the behavioural response of the animal, deep pain sensation was recorded to be present or absent.

### 3.3.5 Spinal reflexes

**Panniculus reflex:** This was tested by pinching the skin on either side of the dorsal midline over the lumbar spine with fine forceps in a caudal to cranial direction and observing the twitch of the cutaneous trunci muscle on the ipsilateral and the contralateral sides (Fig. 12). The response was recorded as normal, reduced or absent.

**Patellar reflex:** The patellar reflex was tested by placing the dog on lateral recumbency and the limb to be tested held with the left hand in a relaxed position. A knee hammer was used to tap the straight patellar ligament of the knee joint and the jerking of the knee was observed (Fig. 13). The test was repeated on the other side with the dog lying on lateral recumbency on the opposite side. The reflex was recorded as increased, normal, reduced or absent.

**Flexor reflex:** The dogs were restrained in lateral recumbency and the upper hind limb was held in a relaxed position and the toes pinched with
fingers (Fig. 14). The ability of the animal to withdraw the paws by flexing the hock and stifle joints was recorded as increased, normal, reduced or absent.

**Anal sphincter reflex:** The perineal and the perianal skin was pinched gently using artery forceps and the ability of the external anal sphincter to contract was recorded as normal, reduced or absent (Fig. 15).

### 3.3.6 Grading of patients

Dogs with spinal trauma were graded on a five grade scale based on their neurological status as follows:

- **Grade 1** – Pain only
- **Grade 2** – Ataxia, conscious proprioceptive deficit and paraparesis
- **Grade 3** – Paraplegia
- **Grade 4** – Paraplegia with urine retention and overflow
- **Grade 5** – Paraplegia, urine retention and overflow and loss of deep pain sensation

Only dogs with grades 3 to 5 of neurological dysfunction were considered for the present study.

### 3.4 Radiographical examination

After attempting to localize the spinal lesion by physical and neurological examination, the dogs were subjected to survey radiography after sedation with triflupromazine hydrochloride (Siquil®, Sarabhai-Zydus Animal Health Ltd., Vadodara) at the rate of 1 mg per kg body weight intravenously.

#### 3.4.1 Plain radiography

Lateral and ventro-dorsal view radiographs of regions of the vertebral column suspected to have lesions were obtained. Lateral view radiographs of the vertebral column were obtained with the dogs on
lateral recumbency, with the fore and hind limbs parallel to each other and stretched cranially and caudally respectively. Sponges were used to reduce the curvature of the spine only if the curvature was too much. Vento-dorsal view radiographs were obtained with the dogs on dorsal recumbency with the fore and hind limbs parallel to each other and stretched cranially and caudally respectively. However, care was taken to prevent overstretching of the vertebral column to avoid further damage to the spinal cord.

### 3.4.2 Myelography

After plain radiography, the patients were subjected to myelography to determine the extent of compression of the spinal cord and to localize lesions. This procedure was undertaken only if the owners consented for the same after being appraised about the risks involved in the procedure. The contrast agent used for myelography in this study was iohexol (Omnipaque®, 350 mg I/ml, Amersham health, Cork, Ireland) (Fig. 16).

An area of skin extending from the caudal aspect of the skull anterior to the occipital protuberance to the level of the axis and extending on either side of the dorsal midline beyond the level of the edges of the wings of the atlas was shaved. The dogs were premedicated with diazepam (Calmpose®, Ranbaxy Laboratories Ltd., New Delhi) at the rate of 0.5 mg per kg body weight intravenously and atropine (Atropine sulphate injection I.P., Superb Drugs Private Ltd., Kolkata) at the rate of 0.04 mg per kg body weight subcutaneously. Anaesthesia was induced with a 2.5 percent solution of thiopentone sodium (Thiosol®, Neon Laboratories Private Ltd., Mumbai) given to effect intravenously. Anesthesia was maintained with a 2.5 percent solution of thiopentone sodium.
The volume of iohexol was calculated at the rate of 80 mg of iodine per kg body weight.

The dogs were restrained on lateral recumbency with the dorsal midline of the neck in line with the table edge. The shaved area of the skin was prepared aseptically by applying tincture of iodine. The head was flexed so that the skull was at 90 degrees to the cervical vertebrae. The nose was kept parallel to the table top (Fig. 17). The outer margins of the wings of the atlas were palpated with the thumb and middle finger of the left hand. The occipital protuberance was palpated with the index finger (Fig. 18). One imaginary line was made to join the outer margins of the wings of the atlas and another line was imagined to run perpendicularly to the first line from the occipital protuberance. A 1.5 inches long 22 gauge hypodermic needle was introduced at an angle of 90 degrees to the skin at a point midway between the occipital protuberance and the point of intersection of the two imaginary lines. The needle was pushed gently through the musculature and finally the subarachnoid space was punctured. The cerebrospinal fluid was allowed to flow out drop by drop. The drops were collected using a sterile syringe as they left the hub of the needle (Fig. 19). After a volume of cerebrospinal fluid equal to the calculated volume of iohexol was collected, the contrast agent was injected slowly into the cisterna magna (Fig. 20). As soon as the administration of the drug was over, the neck was straightened and the dog was positioned so that it was lying at an angle of about 15 degrees with the head up (Fig. 21). This position was retained for about 10 minutes and lateral and ventro-dorsal projections of the affected part of the vertebral column were obtained as in plain radiography. The dogs were then placed again at an inclined position as above and similar projections obtained again after 30 minutes from the time of administration of the contrast agent. Subsequently, the dogs were placed on lateral recumbency and allowed to recover from anaesthesia.
3.5 Advanced imaging techniques

Attempt was made to subject the dogs to advanced diagnostic techniques like digital radiography, computed tomography and magnetic resonance imaging if the owners were willing to undertake the same in spite of the expenses involved.

3.6 Grouping of Patients

After identifying the spinal lesion responsible for the spinal cord damage based on the physical, neurological, radiographical and myelographical examination of the dogs, they were allotted randomly to the surgical treatment groups I and II and to the non-surgical group based on the willingness of the owner for subjecting their pet to surgery as follows.

3.6.1 Group I – Modified spinal stapling and tension band wiring without hemilaminectomy: The affected part of the vertebral column was stabilized by modified spinal stapling and tension band wiring without hemilaminectomy.

3.6.2 Group II – Modified spinal stapling and tension band wiring with hemilaminectomy: The affected part of the vertebral column was stabilized by modified spinal stapling and tension band wiring, and decompression of the spinal cord was achieved by hemilaminectomy.

3.6.3 Group III – Those dogs whose owners were not willing to subject their pets to myelography or surgery either due to economic or emotional reasons were allotted to this group. The dogs were subjected to ultrasound therapy in the region of the affected spine at the rate of 1.5 watts / square centimeters for 10 minutes on alternate days during the observation period of eight weeks. They were also put on cage rest and treated medically with methylprednisolone acetate (Depo-Medrol®, Pharmacia N.V./S.A., Belgium) administered epidurally at weekly
intervals and B complex vitamins (Tab. Neurobion®, Merck Ltd., Goa) twice daily orally.

The poor prognosis for neurological recovery in dogs with Grade 5 injury was explained to the owners and these dogs were included in the study only if the owners insisted on surgical or non-surgical treatment to be undertaken on their pets. Otherwise these dogs were euthanized or returned to the owner without treatment based on the desire of the owner.

3.7 Surgical procedure

3.7.1 Surgical instruments and materials used for surgery

Bard-Parker (BP) blades (No. 11 and No. 22), general surgical instruments, Freer periosteal elevators, two-pronged muscle retractors, Backhaus towel clamps, bone curette, nerve hook, rongeurs, hand chuck and key, bone holding forceps and wire twister-cum-cutter were the instruments used for the surgical procedure (Fig. 22, 23 & 24). The implants used were Steinmann pins, K-wires and stainless steel orthopaedic wires (Fig. 25). All instruments and the implants were sterilized by autoclaving immediately before surgery. Miscellaneous materials used during the surgery included chromic catgut (Mersutures®, Johnson and Johnson, Mumbai), polyamide sutures (Linex®, Futura Surgicare Pvt. Ltd., Bangalore) and bone wax (Bone wax®, Johnson and Johnson, Mumbai).

3.7.2 Pre-operative preparation

Food and water were withheld from all the dogs for a period of 12 hours pre-operatively. The skin over the back from the level of scapula to base of tail was prepared by clipping and shaving. The skin was scrubbed well with soap and water and painted with tincture of iodine. Ceftriaxone (Vetaceph®, Petcare, Bangalore) was injected at the rate of 20
mg per kg body weight intravenously before premedication and induction of anaesthesia.

3.7.3 Premedication and anaesthesia

All dogs were premedicated with atropine sulphate at the rate of 0.04 mg per kg body weight subcutaneously and diazepam at the rate of 0.5 mg per kg body weight intravenously. Anaesthesia was induced and maintained with a 2.5 percent solution of thiopentone sodium given to effect.

3.7.4 Positioning of the dogs for surgery

The dogs were placed on sternal recumbency on the operation table with their fore and hind legs secured to the table by means of cords. A pillow made of folded cloths was placed below the level of the injured spine under the body of the dogs to help easy reduction of the fractured or displaced vertebrae. Sand bags covered with sterile plastic sheets were placed on either side of the dogs to retain them on an upright position. The dogs were draped with a sterile drape extending from neck to tail. An intravenous infusion of Ringer lactate solution (Ringer lactate, Albert David, Kolkata) was maintained throughout the period of surgery at the rate of 10ml/kg b.wt./hour.

3.7.5 Surgical technique

A dorsal midline skin incision was placed using No. 22 BP blade extending from the level of three vertebrae cranial to the level of three vertebrae caudal to the site of injury (Fig. 26). The incision was extended into the subcutaneous fat to the level of the thoracolumbar fascia (Fig. 27). The subcutaneous fat was cleared from the thoracolumbar fascia using dry gauze mops (Fig. 28). No. 11 BP blade was used to incise the fascia on either side of the tips of two dorsal spinous processes cranial and two dorsal spinous processes caudal to the lesion, and the supraspinous ligaments along the length (Fig. 29). Care was taken to
preserve the supraspinous and the interspinous ligaments. The epaxial muscles were bluntly elevated from either side of the dorsal spinous processes and the dorsal lamina of the vertebral arches of two vertebrae cranial and two vertebrae caudal to the site of injury using periosteal elevators (Fig. 30 & 31). The epaxial muscles were elevated from the vertebrae to below the level of the intervertebral foraminae in dogs of Group II to perform hemilaminectomy. In this case the muscles attaching around the articular processes were incised using no. 11 BP blade before they were elevated using periosteal elevators.

Haemostasis was achieved by crushing bleeding points with artery forceps, and by ligation of major bleeding vessels. Muscular attachments on the mammillary and accessory processes were left intact in patients in which hemilaminectomy was not performed. When the muscles were reflected to below the level of the intervertebral foramina, the spinal nerves emerging from them were protected from damage by retracting with nerve hook. The dissected muscles were kept away from the surgical site using two-pronged muscle retractors.

3.7.6 Reduction of displaced vertebrae

The displaced vertebrae were reduced either manually or by retracting the vertebrae by holding the dorsal spinous processes of the vertebrae adjacent to the lesion using Backhaus towel clamps. When the displacement was too much, the reduction was assisted by an assistant raising the site of injury by lifting the abdomen of the animal from underneath, and simultaneous manipulation of the affected vertebrae. Whenever the articular processes of the vertebrae were intact, care was taken to bring the adjacent articular processes to anatomical alignment.

3.7.7 Modified spinal stapling and tension band wiring

K-wire or Steinmann pins ranging from 2 mm to 3 mm in diameter depending on the size of the dog were used for performing the modified
spinal stapling. After selection of the implant, a hole of the same
diameter as that of the implant was drilled on the dorsal spinous process
of the second vertebra caudal to the site of injury, close to the dorsal
arch (Fig. 32). The selected implant was then introduced into the drilled
hole on the dorsal spinous process. The implant was then bent into a “U”
shape either manually or with the help of a bone holding forceps (Fig. 33).
Smaller holes for passing 22 gauge or 20 gauge stainless steel
orthopaedic wires, depending on the size of the dog, were drilled using
appropriate K-wires on the dorsal spinous processes close to the dorsal
arches of the three vertebrae cranial to the first one.

The “U” shaped implant was placed down cranially into the groove
formed by the dorsal spinous processes and the articular processes of
the four vertebrae, with its two arms lying parallel to the dorsal spinous
processes. The implant was kept pressed down and a long piece of
orthopaedic wire was passed through the holes in the dorsal spinous
processes adjacent to site of injury in a figure of “8” fashion. For this, the
wire was first passed from one side of the vertebral column to the other.
The insertion end of the wire was then passed back to the initial
insertion side over the “U” shaped implant across the site of injury and
then passed through the hole on the dorsal spinous process of the
adjacent vertebra. The insertion end of the wire was then brought out
through the opposite side of the vertebra and the free ends were twisted
and tightened to form a figure of “8” tension band over the site of injury
(Fig. 34).

A smaller length of orthopaedic wire was passed through the hole
in the cranial most dorsal spinous process. The ends of the wire were
twisted using a wire twister-cum-cutter around the cranial most ends of
the “U” shaped implant, so that the dorsal spinous process and the
cranial end of the implant were secured together tightly (Fig. 35). The
wires were passed through the interspinous ligament just above the level
of the “U” shaped implant so that the ligaments were preserved. The implant in situ after completion of spinal fixation is depicted in Fig. 36 and 37.

3.7.8 Hemilaminectomy

In Group II, a hemilaminectomy was performed before implant application on the side towards which the spinal cord was being compressed if it could be identified on myelography. Whenever lateralization of the lesion could not be made after myelography, hemilaminectomy was performed on the left side of the site of injury.

The epaxial muscles were reflected to below the level of the articular joints (Fig. 38). The cranial articular process of the caudal vertebra and the caudal articular process of the cranial vertebra at the selected site for hemilaminectomy were removed using a large pair of rongeurs (Fig. 39). The spinal nerve could be clearly visible at this stage as it emerged through the intervertebral foramen (Fig. 40). A fine pair of rongeurs was introduced into the intervertebral foramen taking care not to injure the spinal nerve and the lamina cranial and caudal to the intervertebral foramen, the synovial joints of the articular processes and the lamina cranial and caudal to them were nibbled away carefully to expose the injured spinal cord (Fig. 41 & 42). The laminectomy was extended half way into the cranial and caudal vertebrae, and close to the base of the dorsal spinous process dorsally. Pieces of bones or intervertebral disc material that had entered the spinal canal and impinging on the spinal cord were removed using mosquito forceps or bone curette. Excess bleeding from the cut cancellous bone on the laminectomy site was controlled by pressing bone wax on the bleeding points. The laminectomy defect was filled with a free fat graft procured from the lumbar fat depot away from the site of incision (Fig. 43).
3.7.9 Wound closure

The epaxial muscles were apposed using No. 1 chromic catgut applied in a simple interrupted fashion. The incision on the fascia was closed using No. 1 chromic catgut applied in a simple interrupted fashion. Subcuticular sutures were applied in a continuous fashion using No.1-0 chromic catgut. Special care was taken to obliterate dead space formed during the harvesting of the free fat graft using continuous sutures. The skin incision was closed using polyamide sutures applied in a simple interrupted fashion.

3.7.10 Post-operative care

Povidone iodine ointment (Betadine®, Win-Medicare Ltd., New Delhi) was applied to the suture line and sterile gauze pads applied with adhesive tapes. Ceftriaxone was administered twice daily intravenously at the rate of 20 mg per kg body weight for five days post-operatively.

The wound was dressed on alternate days by cleaning the suture line with surgical spirit and application of povidone iodine ointment and sterile pads. Whenever seroma formation was seen at the site of surgery, the accumulated fluid was drained through gaps made at the ends of the suture line. The subcutaneous space was then thoroughly lavaged using sterile normal saline solution. If signs of infection were present, gentamicin (Gentamicin, TTK Healthcare Ltd., Chennai) was added to the flushing solution at the rate of 200 mg per 500 ml.

The bladder was pressed through the abdomen and the urine relieved whenever the dog was cystoplegic, at least three times a day. The dogs were turned every two to three hours during the day till they were able to turn on their own to prevent formation of decubital ulcers. They were also provided soft bedding to reduce pressure on the soft tissue over bony prominences. Already formed decubital ulcers were cleaned twice daily with povidone iodine topical solution and povidone iodine ointment
was applied. Passive physiotherapy was started from the third postoperative day in the form of massaging of the hind limb muscles and flexion and extension of the joints for ten minutes twice daily.

3.8 Non-surgical treatment

The skin over the affected part of the vertebral column was shaved to extend over a length of three vertebrae cranial and caudal to the site of injury, and on either side of the midline one inch beyond the level of the lateral margins of the transverse processes. The dogs were placed on sternal recumbency on a table and physically restrained. Ultrasound gel was applied on the prepared skin. The ultrasound therapy machine (Lifesonic-T, Lifeline Systems, Madras) (Fig. 44) was set to 1.5 watts per square centimeters and the time set to 10 minutes. The transducer was placed on the skin over the gel and moved slowly on the dorsal aspect and on either side of the spinal column throughout the prepared area (Fig. 45). The process was repeated on alternate days for a period of two months following initiation of treatment.

The dogs were also administered methylprednisolone acetate epidurally in the lumbosacral epidural space. The skin over the lumbosacral space was prepared aseptically by shaving the hair and application of surgical spirit. The dogs were controlled manually on sternal recumbency on a table with the hind limbs extended forwards. The cranial edges of the wings of the ilia were palpated with the thumb and middle fingers of the left hand, and the dorsal spinous process of the seventh lumbar vertebra palpated with the index finger at the level of a line joining both the wings of the ilia. A 22 gauge 1.5 inch hypodermic needle was introduced at 90 degrees to the skin slightly caudal to the dorsal spinous process of the seventh lumbar vertebra. The needle was advanced until it penetrated the ligamentum flavum. Methylprednisolone acetate was injected at the rate of 2 mg per kg body weight into the epidural space. The location of the tip of the needle in the epidural space
was confirmed by the free flow of the drug. The injections were repeated at weekly intervals for a period of two months.

All dogs were administered B complex vitamins orally twice daily for a period of two months following initiation of treatment.

Further, these dogs were subjected to passive physiotherapy in the form of massaging of the muscles of the hind legs and extension and flexion of the joints. All the dogs were provided cage rest during the study period.

3.9 Post-treatment evaluation

All the dogs were evaluated post-operatively for a period of eight weeks.

3.9.1 Clinical examination

Temperature, heart rate and respiratory rates were recorded on the 15th, 30th, 45th and 60th days.

3.9.2 Neurological examination

The dogs were evaluated for improvement in locomotor status, conscious proprioception, reflexes and pain sensation on the 15th, 30th, 45th and 60th days. Based on their neurological function their grades were reassessed.

3.9.3 Radiographical evaluation

Plain radiographs of the operated site of the vertebral column were obtained on the 1st, 15th, 30th, 45th and 60th days to assess the stability of implants and signs of healing at the site of injury.

3.10 Haematological studies

Two milliliters of blood was collected in EDTA containing sterile vials on the day of presentation and on the 15th, 30th, 45th and 60th days after surgery to evaluate for haemoglobin (g/dl), packed cell volume (%),
total erythrocyte count (millions/cmm.), total leukocyte count (thousands/cmm.) and differential leukocyte count (% of individual cells).

Haemoglobin concentration was estimated using Sahli's haemoglobinometer and packed cell volume was estimated by microhaematocrit method according to the procedures described by Benjamin (2001).

Total erythrocyte count and total leukocyte count were estimated according to the procedure described by Benjamin (2001). Differential leukocyte count was performed on Giemsa stained blood smears. One hundred cells were counted and the percent of each type of cell obtained as per the procedure described by Benjamin (2001).

3.11 Serum biochemistry

Three milliliters of blood was collected in sterile vials and the serum separated and subjected to estimation of serum inorganic calcium (mg/dl), phosphorus (mg/dl), potassium (mg/dl) and serum enzymes like serum alkaline phosphatase (U/L), alanine aminotransferase (U/L) and aspartate aminotransferase (U/L) by spectrophotometric method using automatic analyzer on the day of presentation, and on the 15th, 30th, 45th and 60th days after surgery or initiation of non-surgical treatment.

3.12 Cerebrospinal fluid analysis

The cerebrospinal fluid collected on the day on which myelography was performed was examined for colour and clarity. Specific gravity was determined using a refractometer as done by Widmer et al. (1992). Cell count (per µl) was performed using a haemocytometer as done by Thomson et al. (1989). Cell type was studied using smears of centrifuged samples to which serum was added and stained with Giemsa stain as described by Benjamin (2001). Total protein content (mg/dl) was estimated using a spectrophotometer.
3.13 Statistical analysis

Data obtained from haematological studies, serum biochemistry and analysis of cerebrospinal fluid were subjected to statistical analysis by One Way ANOVA to compare the values obtained in dogs between different days of study within each group and between same days of study of different groups for significance using the software GraphPad Prism (GraphPad Software Inc., USA).