5.0 DISCUSSION
The efficacy of modified spinal stapling and tension band wiring with or without hemilaminectomy for the treatment of traumatic paraplegia in dogs was evaluated and compared with non-surgical treatment in 18 clinical cases of traumatic posterior paralysis in dogs and the results are discussed as follows.

5.1 Occurrence
Among the 14,442 dogs presented to the College Hospital during the study period of two years, 47 (0.33%) cases were paraplegia of traumatic origin in dogs. Riaz (2004) observed that about 0.65% of the cases presented to the same hospital over a one year study period were paraplegic dogs. The difference in the occurrence recorded in the previous study and the present one was probably because of the fact that the former considered all cases of paraplegia, whereas the present study included only cases of traumatic paraplegia.

The highest breed-wise occurrence of the condition was seen in non-descript dogs (46.81%) followed by spitz (17.02%), German Shepherd Dogs (8.51%), Labrador Retrievers (8.51%), Dachshunds (6.37%) and Boxers (4.26%). One each of Dalmatian (2.13%), Cocker Spaniel (2.13%), Great Dane (2.13%) and Doberman Pinscher (2.13%) breeds were also presented. The highest occurrence of the condition in non-descript dogs may be explained by the fact that most of them lived in a semi-stray condition. These dogs spent most of their time in the streets where they were more susceptible to external trauma. This finding is in accordance with that of McKee (1990) who also reported a high incidence of spinal trauma in mongrel dogs (17.07%). But, the occurrence of the condition in non-descript dogs in this study was higher compared to that reported by McKee (1990). Carberry et al. (1989) reported a higher incidence (33.33%) of vertebral fractures and luxations in mixed breeds of dogs. A similar occurrence (33.33%) of vertebral fracture in mixed breed dogs was
reported by Ullman and Boudrieau (1993). However, Riaz (2004) observed the highest occurrence of paraplegia in German Shepherd Dogs (52.17%). This may have been because of the higher occurrence of paraplegia due to non-traumatic origin in this breed during the period of study.

Among the pure bred dogs, the higher occurrence of the condition in spitz dogs may be because of the popularity of the breed in and around Bangalore. The lower occurrence of the condition in other pure bred dogs may be because they were kept mostly indoors or confined within the premises of the owners’ house.

Though Dachshunds are considered to be more prone to intervertebral disc disease as reported by Yovich et al. (1994), (51%) and Necas and Sedlakova (1999), (73.2%); the presentation of only three (6.37%) of these dogs with paraplegia in the present study may be due to a lesser popularity of this breed in and around Bangalore.

In the present study, it was found that younger dogs were more prone to traumatic spinal cord injury. The occurrence was 25.53 percent in dogs between zero and three years of age, 25.53 percent in dogs between three and six years of age, 21.28 percent in dogs between six and nine years of age, 23.40 percent in dogs between nine and twelve years of age, and 4.26 percent in dogs between twelve and fifteen years of age. This may be because of the fact that younger dogs are more active and hence more prone to external trauma. Similarly, higher occurrence of traumatic spinal injuries in younger dogs have been reported by Carberry et al. (1989) who reported that the median age of occurrence of the condition among 12 dogs was two years and McKee (1990) who observed that 50 percent of 51 dogs and cats with spinal trauma were less than two years old. Riaz (2004) observed that the average age of occurrence of paraplegia in dogs was 6.5 years with a range from 8
months to 12 years. In the present study the age of occurrence ranged from two months to 13 years and four months.

Thirty two (68.09%) dogs with traumatic paraplegia were males while 15 (31.91%) were females. The higher incidence of the condition in male dogs may be because of the preference of people to keep more male dogs as pets than females. A slightly higher occurrence of thoracolumbar disc disease in males than in females has been reported by many authors (Yovich et al., 1994; Muir et al., 1995; Necas and Sedlakova, 1999). However, McKee (1990) reported a higher incidence of traumatic spinal injuries in female dogs and cats (29/51, 56.86%). This difference may be explained by the fact that the latter report was from a western country where people may not have a specific preference for male dogs over females.

In the present study, the body weights of the dogs with spinal injuries ranged from 3 to 45 kg. In a study by Carberry et al. (1989) body weights of dogs included for study ranged from 4.5 to 35 kg. Ullman and Boudrieau (1993) reported L7 vertebral fracture in six dogs whose body weights ranged from 19 to 35 kg.

5.2 Aetiology for traumatic posterior paralysis

In the present study, the most common cause for traumatic paraplegia in dogs was automobile accidents (53.19%). This was an acceptable finding since the most commonly affected dogs were non-descript native dogs which lived in a semi-stray condition and hence more prone to have encounters with automobiles. Dogs kept indoors got involved in automobile accidents when they got loose and ran into the streets. Carberry et al. (1989) reported that 88.24 percent of spinal injuries in dogs and cats occurred following automobile accidents. McKee (1990) reported that 58.82 percent of spinal trauma in dogs and cats occurred after being hit by cars. The second most common cause for
traumatic paraplegia in dogs in this study was falling from height (19.15%). Carberry et al. (1989) observed that 5.88 percent of spinal cord injury in small animals occurred due to falling from height. Most of the dogs of the present study got injured after sustaining severe trauma to the spine due to fall from great heights (first to third floor). Two dogs became paraplegic after falling from smaller heights like from table and chair because of innate pathology of the vertebrae in the form of osteodystrophia fibrosa and hemivertebrae. Secondary hyperparathyroidism has been recognized as a cause for vertebral fractures following inability of vertebrae to withstand even normal physiological forces (Hazewinkel, 1989) or falling from small heights as a case of a cat the sustained spinal injury after jumping from the owners hand as reported by McKee (1990). In the present study, one (2.13%) dog each got injured after being attacked by man and dogs. Carberry et al. (1989) also reported a low occurrence of spinal injury due to attack by dogs (5.88%). However, McKee (1990) reported a higher occurrence of similar injury in dogs following dog fight (14.63%). Jeffery and Blakemore (1999) also recounted that acute spinal cord injury might result from external trauma such as road traffic accidents or falls. Jaderlund et al. (2002) reported spinal cord trauma due to T3-T4 intervertebral disc herniation in a dog following a fall when running at high speed on wet surface. Voss and Montavon (2004) reported that 97.37 percent of 38 dogs and cats with spinal trauma sustained the injury following road traffic accidents and falls, while the remaining got injured after getting bitten on the back.

Dogs that had a sudden onset of paraplegia but no clear history of external trauma were diagnosed as having intervertebral disc disease either on survey radiographs or on myelograms. McKee (1990) observed that 9.8 percent of 51 dogs and cats sustained spinal trauma due to unknown reasons. Kinzel et al. (2005) noted that herniation of the intervertebral disc was the most common cause of neurological trauma
in dogs. The disease may be characterized by sudden onset of paraplegia with the owner being unable to link the condition to any specific incident. Any of the imaging techniques would be required to identify the actual cause for spinal cord injury.

5.3 Source of animals for the study

In the present study dogs were presented 1 day to 47 days after sustaining spinal trauma. In the study conducted by McKee (1990) paraplegic animals were presented between less than one day of injury and three weeks of injury. The variation in the time from injury to presentation was wide in both studies. However, in the present study the duration was more than three weeks in four dogs (25 days to 47 days). This delay in presentation resulted from the remote location of the patient owners’ homes from the College Hospital or unawareness of owners about the treatment options available during the early stages of the disease. Bagley (2000) had discussed the importance of early initiation of treatment for spinal cord trauma to improve the prognosis. The study conducted by Laverty et al. (2004) consisted of paraplegic dogs presented within 72 hours of occurrence of paraplegia. Similar selection criteria would have assured more uniformity to the studied groups.

For ideal clinical comparison and statistical evaluation of populations subjected to different treatment protocols for spinal cord injury, the subjects of study should form uniform populations with comparable physiological parameters, similar types of injury and duration of illness, which was impossible in the present study because the study was conducted on clinical cases. For effective comparison between different groups, similar studies should be conducted in experimental animals.

In the present study, allotment of dogs into Group I and II was done randomly, whereas allotment of dogs to Group III was done based
on unwillingness of the owners to subject their dogs to surgery and due to economic considerations. A similar method for selection of dogs to study the efficacy of surgical and non-surgical treatments in dogs with traumatic paraplegia was used by Riaz (2004). The conduction of this study in clinical cases of spinal cord trauma as they were presented without taking into consideration the uniformity of the groups, though less than ideal, was humane and clinically inevitable.

5.4 Physical examination

Physical examination by palpation of the affected part of the vertebral column as suggested by Wheeler and Sharp (1994) was very useful in tentatively determining the site of vertebral injury based on the elicitation of pain in dogs with fractures or subluxations. Pain could not be elicited easily in all dogs with intervertebral disc disease probably due to the fact that the vertebral column was relatively stable at the site of injury in these cases.

5.5 Clinical examination

5.5.1 Rectal temperature (°F)

In the present study, the mean rectal temperatures ranged between 102.00 ± 0.14 to 102.20 ± 0.13, 101.90 ± 0.16 to 102.60 ± 0.34 and 101.80 ± 0.19 to 102.20 ± 0.07 in Group I, II and III respectively. The means fell within the normal physiological range in all dogs of the three groups on all the days of evaluation. This indicated that paraplegia had no effect on rectal temperature. Gage (1968) reported that the rectal temperature of a tetraplegic dog that had sustained a cervical vertebral fracture was 102.2°F. Riaz (2004) also observed no significant variation in rectal temperatures in dogs between the days or groups during his study involving surgical and non-surgical treatment of paraplegic dogs. However, two dogs of Group II had elevated rectal temperature on the day of presentation. Both dogs were females and had cloudy urine with
flakes of pus on the day of presentation indicating cystitis. In one of them the urine was blood tinged also. Both these dogs responded to antibiotic therapy and the rectal temperatures returned to normal by the third day of treatment.

5.5.2 Heart rate (beats per minute)

The mean heart rates of the dogs ranged from 111.30 ± 2.95 to 112.70 ± 2.68, 110.70 ± 2.92 to 111.70 ± 2.50 and 116.30 ± 0.95 to 118.30 ± 1.59 in Group I, II and III respectively. These values also fell within the normal physiological range throughout the study period in all three groups. This was because of the fact that all the dogs included in the study had spinal cord injuries in the caudal thoracic or lumbar segments which did not interfere with the sympathetic supply to the heart. Hence, the sympathetic and parasympathetic control of heart function was unaffected in any of these dogs. Similarly, no significant variation in heart rates between days of study or groups were observed in paraplegic dogs by Riaz (2004).

5.5.3 Respiratory rate (breaths per minute)

The mean respiratory ranged from 26.67 ± 1.56 to 27.83 ± 1.49, 28.00 ± 1.69 to 29.00 ± 1.44 and 26.00 ± 1.41 to 28.00 ± 1.39 in Group I, II and III respectively during the study period. The values were within the normal physiological limits throughout the study period. This was because of the fact that in none of these cases the spinal cord segments involved with innervation of the respiratory muscles were affected. The findings were in accordance with that of the study conducted by Riaz (2004) where the respiratory rates remained within the normal range throughout the study period in paraplegic dogs treated surgically or non-surgically.
5.5.4 Bladder function

Of the 18 dogs studied in the three groups only two (11.11%) had normal bladder function at the time of presentation. Twelve dogs (66.67%) had UMN bladders and the remaining four (22.22%) had LMN bladders at the time of presentation. Return of normal bladder function was found in all dogs except two dogs each of Group II and III by the 15th day itself. All dogs in Group I and II had normal bladder function by the 30th post-operative day, while the two dogs in Group III continued to have abnormal bladder function till the end of the study period. It was found that improvement in bladder function was seen within the first three days itself in all the dogs that showed return of bladder function within 15 days. Bladder function returned in paraplegic dogs before return of voluntary movements in the limbs or tail. This suggests that return of voluntary urination could be considered as an early clinical indicator for return of neurological function in paraplegic animals. However, Riaz (2004) observed return of normal bladder function in paraplegic dogs in later days. In his study, four dogs subjected to non-surgical treatment started bladder function by four weeks after initiation of treatment and one dog subjected to surgical treatment started bladder function by two weeks after the surgery.

The evaluation of bladder function was found to be efficient in assessing the neurological recovery in dogs of the three groups. All the dogs treated surgically had normal bladder function by the end of the study period. Two dogs of Group II had abnormal bladder function on day 15 while all dogs had returned to normal bladder function by that time in Group I. This does not indicate the superiority of the method of treatment used in Group I as these dogs of Group II were presented 30 and 47 days after spinal cord injury and because of the prolonged duration of cystoplegia the bladder and urethral muscles probably required more time for return to normal function. Two dogs of the non-
surgical group did not have normal bladder function even at the end of the study period indicating that non-surgical treatment was not as effective for neurological recovery as surgical treatment for traumatic paraplegia in dogs.

5.6 Neurological examination

The method adopted for neurological evaluation of the patients as suggested by Wheeler and Sharp (1994) based on attitude, posture and gait; locomotor status; conscious proprioception and deep pain sensation was highly efficient in assessing the degree of damage to the spinal cord and prognostication of the patients. The studying of spinal reflexes was very useful in localization of injuries and assessing the neurological recovery of the dogs throughout the study period. Wright (1980) had noted the importance of neurological signs in reflecting the site of spinal injury and the degree of spinal cord damage. McKee (1990) stressed that an animal with traumatic spinal injury should be assessed based on neurological examination rather than radiographical findings as in some cases there was poor correlation between the degree of displacement of vertebrae observed and the severity of neurological dysfunction recorded.

Ferreira et al. (2002) graded paraplegic dogs to have excellent outcome following treatment if they regained the ability to walk without proprioceptive deficits. In the present study, a dog was considered to have recovered completely if it could stand up on its own, ambulate and engage in basic activities like feeding, defecation and urination on its own. Results of neurological examination throughout the study period indicated that dogs of Group II showed marginally better neurological improvement as only one of the dogs did not regain normal function when compared to those of Group I in which two dogs did not recover completely. However, all the three dogs had showed partial neurological recovery post-operatively. This indicates that spinal stabilization with decompressive surgery may be better than without decompressive
surgery in increasing the chances of neurological recovery in paraplegic
dogs. In Group III only two dogs had recovered completely, while three
had partial recovery and one dog deteriorated during the period of study.
Both the dogs that recovered completely and one of the dogs that showed
partial recovery in Group III had intervertebral disc disease. Neurological
deterioration of the dog of Group III with vertebral subluxation during
the study period indicated that non-surgical management may not be as
effective as surgical treatment for traumatic paraplegia in dogs with
instability of the vertebral column. The complete neurological recovery of
two out of three dogs with intervertebral disc disease treated by non-
surgical method indicates that the method may be useful for routine
treatment of such cases, especially if the degree of compression of the
spinal cord was less.

Of all the neurological parameters studied, presence or absence of
deep pain sensation proved to be a very useful prognostic indicator for
neurological improvement as suggested by Muir et al. (1995), Duval et al.
(1996), Bergman et al. (2000), Lanz et al. (2000), Jefferey et al. (2001)
and Voss and Montavon (2004). In the present study, all dogs that did
not have deep pain sensation in hind paws except one each in Group II
and III, had to be excluded from the study because of death after
initiation of treatment or lack of neurological improvement leading to
euthanasia upon insistence of the owners within the 15th day of
evaluation. In effect, only two dogs without deep pain sensation in the
hind paws were included in this study. Of these, the dog in Group III
with vertebral fracture continued to be in the same state till the end of
the study period. This was in accordance with the opinion of Jeffery et al.
(2001) who noted that animals that had lost deep pain sensation in
association with vertebral fractures and luxations were less likely to
recover neurological function. This dog did not have any chance at all
especially because the owner was unwilling to subject the dog to surgical
stabilization of the injured vertebral column. The dog in Group II had intervertebral disc prolapse and was recorded to have deep pain sensation in the left hind paw by the 15\textsuperscript{th} post-operative day indicating partial neurological recovery. Davis and Brown (2002) had reported that the relationship between loss of deep pain sensation and prognosis for return of pelvic limb function was not significant as far as intervertebral disc disease was concerned. Earlier, Muir \textit{et al.} (1995) had expressed a similar opinion. However, this dog was still paraplegic at the end of the study period supporting the generally accepted notion that dogs without deep pain sensation had poor prognosis for neurological recovery (Bagley, 2000; Bergman \textit{et al.}, 2000; Lanz \textit{et al.}, 2000; Voss and Montavon, 2004; Tartarelli \textit{et al.}, 2005).

Carberry \textit{et al.} (1989) had opined that animals with lower motor neuron dysfunction had a worse prognosis for recovery. However, in the present study, one of the dogs with lower motor neuron paralysis of the hind quarters recovered completely.

\textbf{5.7 Grading of patients}

The method of grading that was used for the study was very useful in prognostication of the patients. It was also efficient in evaluating the progressive improvement in the patients. Similar methods of grading of patients with spinal cord injury have been used by many authors (Griffiths, 1982; Wheeler, 1988; McKee, 1990 and Kinzel \textit{et al.}, 2005).

It was found that four of the dogs had almost normal function at the end of the study period in Group I while five had attained normal neurological function in Group II. This again proved that the performance of decompressive surgery gave marginally better results than when spinal fixation alone was performed. In Group III, only two dogs, both having intervertebral disc disease, were graded 1 by the end of the study period indicating the fact that non-surgical management of
traumatic posterior paralysis may yield favourable results only in mild cases of spinal cord compression as in cases of intervertebral disc disease where there was no instability of the vertebral column. Non-surgical treatment could not be expected to help dogs suffering from traumatic paraplegia having instability of the vertebral column in the form of subluxations, luxations or fractures.

5.8 Radiographical examination

5.8.1 Plain radiography

Lateral view radiographs were obtained without difficulty in all the dogs after sedation as suggested by Lanz et al. (2000). However, ventro-dorsal positioning was difficult in all dogs as the position caused increased pain and discomfort.

Vertebral subluxations, vertebral body fractures, fracture-subluxations, fracture-luxations, bilateral cranial articular process fracture and intervertebral disc space reduction were the lesions that could be identified on survey radiographs of the spine of the dogs included in the study. Similar conditions were diagnosed by McKee (1990) and Voss and Montavon (2004) on survey radiographs. However, Carberry et al. (1989) opined that radiographs might be of limited value as prognostic indicators for dogs with spinal trauma as they might not show the maximum displacement that occurred at the time of injury. They noted that spontaneous reduction of subluxations, luxations and fractures might occur prior to radiography. Moreover, inherent stability of any fracture or luxation was difficult to appreciate radiographically. Similar opinions were put forth by McKee (1990) and Lanz et al. (2000). Bagley et al. (2000) opined that serial radiographs and cautious palpation of the spine might be needed to confirm instability following exogenous trauma as instability of the vertebral segment could be difficult to predict from a single radiograph.
Among the dogs included in this study, 77.78 percent were identified to have spinal lesions in the region from T11 to L3 vertebrae. This was similar to the findings of McKee (1990) who observed a high occurrence (39.2%) of traumatic spinal injuries in dogs and cats between T12 and L2 vertebrae. McKee (1992) reported that among 60 dogs with thoracolumbar disc protrusions, the most commonly affected disc was T12/T13 (33%), with T12/T13 to L1/L2 accounting for 75 percent of all protrusions. Scott (1997) reported that 65 percent of thoracolumbar disc disease among 40 dogs occurred between T12 to L1. Macias et al. (2002) observed that among 99 dogs with thoracolumbar disc disease 69 percent of the affected discs were located between T12/T13 and L2/L3. Voss and Montavon (2004) reported following a study in 22 dogs that 63.64 percent of vertebral fractures and luxations occurred between T12 and L3. The high occurrence of injury in the thoracolumbar junction as in the other studies may be because of the fact that thoraco-lumbar region forms a junction between mobile (lumbar) and relatively immobile (thoracic) parts of the vertebral column which makes it highly susceptible to traumatic injury as suggested by Feeney and Oliver (1980) and Lanz et al. (2000). Breit (2002) observed minimal diameters of the spinal canal at L1/L2 junction in large breeds of dogs. The author stressed that this agreed with the occurrence of spinal cord compression most commonly in this region in non-chondrodystrophic large breeds of dogs.

A consistent pattern in the healing of vertebral fractures could not be identified radiographically during the study period. This was in accordance with the findings of Carberry et al. (1989) who reported variable callus formation during healing of vertebral fractures. Moreover, each fracture type was different and could not be expected to heal in a predictable manner. The time from sustaining the injury to presentation of the paraplegic dogs to the Hospital also varied because of which each animal was at a different stage of healing at the site of vertebral injury.
The inability to detect any change in the hemilaminectomy site in dogs of Group II may have been because of successful prevention of accumulation of blood at the site of laminectomy by the use of free fat graft and subsequent prevention of laminectomy membrane formation. McKee (1992), Muir et al. (1995) and Scott (1997) had suggested the use of free fat graft at the site of hemilaminectomy to prevent laminectomy membrane formation.

Progressive formation and consolidation of callus was observed at the site of vertebral subluxation during the period of study in two dogs. Even though only ligamentous injury could be expected in subluxations, the presence of callus at the site of injury in these dogs indicate that there may have been subtle fractures of the vertebral bodies adjacent to the affected intervertebral space which could not be identified by plain radiography. One dog in Group II and three dogs in Group III which had intervertebral disc disease showed no radiographically visible change in the affected part of the spine during the period of study. This was expected as bone involvement may have been absent in all these cases.

Plain radiographs were adequate for evaluation of the technique of implant fixation and stability of the implants. Wise (1999) reported the use of survey radiographs to check the status of vertebral fixation using Steinmann pins and orthopaedic wires 16 months after surgery. Recurrence of subluxation was observed radiographically on the 15th post-operative day in one dog of Group I. However, the neurological status of the dog improved progressively indicating that even though subluxation had recurred, the implant provided sufficient stability at the site preventing further damage to the spinal cord. Separation of the cranial end of the implant from the cranial most dorsal spinous process due to fracture of the spine was seen in another dog of Group I on the 30th post-operative day. This may have happened because the cranial wire was passed closer to the relatively narrow part of the spine which
did not have enough strength to withstand the stressful forces acting at the site of wire tightening. Implant migration from the site of application due to fracture of the caudal most dorsal spine on which the implant was fixed was observed in one dog of Group II on the 30th post-operative day. In the latter the failure of the implant occurred because the dog was young and the bone was too weak to hold the implant. Voss and Montavon (2004) also reported implant failure in a young dog with soft bone due to inability of the bone to hold the implant. Implant failure was identified by radiography by Riaz (2004) also.

5.8.2 Myelography

The anaesthetic protocol used was adequate for restraining all the dogs for myelography. Diazepam reduced the chances of seizures due to irritation of the tissues of the central nervous system by iohexol.

The method adopted for location of the site for cisterna magna puncture as suggested by Wheeler and Sharp (1994) was effective in achieving a successful puncture at the first attempt itself.

Iohexol at the dose used in the study provided excellent contrast for demarcation of the spinal cord on myelograms. The drug had been used in a similar dose by Riaz (2004). Keeping the dogs in a slanted position of about 15° with the head up as suggested by Wheeler and Sharp, (1994) promoted the caudal flow of iohexol and prevented its flow into the brain.

The technique was adequate in all cases in identifying the sites of spinal cord compression. Myelography was a must for identifying intervertebral disc disease as the accuracy for identification of the condition in plain radiographs has been found to be low as reported by Lamb et al. (2002). However, lateralization of the spinal cord compression could not be made in any of the case. Lateralization of the spinal cord compression due to intervertebral disc disease in dogs could be attained
after myelography in only 40 percent and 70 percent of the cases by McKee (1992) and Scott (1997) respectively.

None of the dogs in this study showed post-myelographic complications like seizures and all of them had an uneventful recovery from anaesthesia. This suggests that iohexol is a safe contrast agent for myelography as complications were also not reported by many authors following use of this agent for myelography (Wheeler and Davies, 1985; Scott, 1997; Moore et al., 2000; Lu et al., 2002; Macias et al., 2002; Kumar, 2003 and Riaz, 2004).

5.9 Advanced imaging techniques

Digital radiography, computed tomography and magnetic resonance imaging were found to be much more superior than conventional radiography in arriving at an accurate diagnosis. Computed tomography could help visualize fracture lines which would otherwise have been missed on conventional radiographs as also observed by Lanz et al. (2000). Voss and Montavon (2004) also reported that articular fractures were sometimes not detected by conventional radiography. Magnetic resonance imaging was also superior to conventional radiography in assessing injury to the spinal cord as reported by Gopal and Jeffery (2001). Tartarelli et al. (2005) also opined that magnetic resonance imaging was more accurate for delineating sites of spinal cord compression. The use of magnetic resonance imaging more extensively in veterinary practice may help predict the outcome of treatment in dogs with spinal cord injury as reported by Ito et al. (2005). In a recent report, Platt et al. (2006) was able to identify changes of myelomalacia in the spinal cord of a dog with intervertebral disc extrusion.

However, these diagnostic modalities could not be used in all cases due to their lack of availability to veterinary patients due to social and economical concerns.
5.10 Surgical procedure

5.10.1 Pre-operative preparation

Withholding of food and water for 12 hours pre-operatively was effective in preventing intra-operative complications like aspiration in all cases. The extensive shaving of hair at the surgical site, antiseptic preparation of the site and administration of the antibiotic pre-operatively may have effectively prevented intra-operative infection of the surgical site in all cases. The prophylactic use of antibiotics for extensive neurosurgical procedures has been advocated by Rosin et al. (1993).

5.10.2 Premedication and anaesthesia

Premedication with atropine and diazepam and induction and maintenance of anaesthesia with 2.5% solution of thiopentone sodium was adequate for controlling all dogs effectively for surgery throughout the prolonged periods of surgery. However, the use of inhalation agents like halothane or isoflurane would have been safer in these dogs which underwent prolonged duration of surgery.

5.10.3 Positioning of the dogs for surgery

The method of positioning and restraining the dogs on the table was very convenient for performance of the whole surgical procedure. Similar positioning was recommended by Wheeler and Sharp (1994).

5.10.4 Surgical technique

Length of the skin incision was adequate in all cases. The use of dry gauze mops to clear the adipose tissue from the thoracolumbar fascia was effective in preparing a clean area for further surgical dissection. Incision of the fascia on either side of the tips of the dorsal spinous processes and the supraspinous ligaments and the muscles around the articular processes could be done efficiently with No. 11 BP blades as suggested by Wheeler and Sharp (1994). The supraspinous and
interspinous ligaments were not damaged by the surgical process in any of the cases as recommended by Voss and Montavon (2004). Periosteal elevators could be easily used to bluntly elevate the epaxial muscles from the vertebral spines, laminae and articular processes as suggested by Wheeler and Sharp (1994).

The blunt elevation of muscles prevented unwanted trauma to the muscles, provided clear bone surfaces for implant application and decompressive surgery in Group II, and reduced chances of bleeding from the musculature in both groups. Elevation of the muscles over two vertebrae cranial and caudal to the lesion as reported by Voss and Montavon (2004) was adequate in all cases for the application of implants except four dogs in which an additional vertebra had to be included in the fixation. Fixation of an additional vertebra was a must in the latter dogs to increase the stability of the vertebral column as upon opening of the site of injury it was found that fractures of the dorsal spine of the affected vertebra were present. Bleeding during muscle dissection and elevation could be effectively controlled by crushing the small bleeding vessels with artery forceps or ligation of larger ones with No. 1-0 catgut. However, the use of bipolar diathermy as suggested by Scott (1997) would have minimized bleeding further.

The use of nerve hook was very helpful in preventing damage to the spinal nerves during the dissection. The use of two pronged muscle retractors provided satisfactory retraction of dissected muscles for adequate exposure of the vertebrae during the surgery. But, Gelpi retractors would have provided more efficient retraction of the dissected muscles and exposure of the affected vertebrae as suggested by Wheeler and Sharp (1994). Fractures of the dorsal spinous processes and articular processes which were not visible in the plain radiographs were seen in 2 dogs of Group II after surgical exposure. This was in accordance with the opinion of Carberry et al. (1989) that all fractures of
vertebrae might not always be evident radiographically. Dehydration of the exposed musculature could be prevented effectively by intermittent irrigation with sterile normal saline.

Bagley *et al.* (2000) recommended that surgical treatment for spinal trauma should be considered in animals with spinal instability and/or cord compression related to exogenous trauma. They stressed that as each spinal injury was unique, treatment guidelines needed to be individualized. Lanz *et al.* (2000) recommended that surgical treatment for spinal injuries was indicated when there were substantial neurological deficits and evidence of spinal cord compression based on plain radiography, myelography and computed tomography.

### 5.10.5 Reduction of displaced vertebrae

Even though reduction of displaced vertebrae could be achieved without much difficulty manually or by distracting adjacent vertebrae by holding the dorsal spinous processes of adjacent vertebrae with Backhaus towel clamps, the use of lamina spreaders and neuromuscular blockage during anaesthesia as suggested by Bagley *et al.* (2000) may have made the procedure easier especially in highly displaced vertebral segments. Voss and Montavon (2004) reduced fractures and luxations with the help of Kocher forceps placed on the spinous processes adjacent to the spinal lesion.

### 5.10.6 Modified spinal stapling and tension band wiring

The modified spinal stapling and tension band wiring was performed without any difficulty in all dogs as suggested by Voss and Montavon (2004). These authors had recommended this technique in animals less than 20 kg body weight. They noted that the fixation strength might be insufficient to stabilize certain fracture types and ancillary external or internal fixation methods might be needed especially in larger dogs. However, in the present study one Great Dane dog
weighing 45 kg which was treated with this technique in Group II went on to have complete neurological recovery. This was because of the fact the dog had a stable vertebral fracture which was already healing as the dog was presented after 47 days of sustaining the injury. Here, the hemilaminectomy helped neurological recovery by relieving the compression on the spinal cord by the callus and the fixation technique prevented further instability at the site of injury.

The performance of spinal fixation in one dog of Group II with intervertebral disc disease after hemilaminectomy may have helped overcome the instability caused by the decompressive procedure and made the vertebral column more stable than if it had been left as such. However, Macias et al. (2002) opined that the role of surgical stabilization of the affected vertebrae in dogs with thoracolumbar disc disease remained unclear, though it had been earlier suggested that it might be useful to prevent further protrusions of the annular material. These authors suggested that vertebral stabilization was more likely to be useful in larger and younger dogs with a single affected disc.

The inclusion of an additional vertebra in the fixation in four dogs with fractures of the dorsal spinal processes of affected vertebrae to increase fixation stability was done without any difficulty. Swaim (1971) had cautioned that if insufficient strength of dorsal spinous processes for implant holding was tried to be overcome by using many spinous processes, the result was a non-physiological spinal fixation as if many vertebrae had been fused into one unit. However, the modification could not be avoided as depending too much on already fractured dorsal spinous processes to hold implants would have increased chances of implant failure. Moreover, it was found during the study that inclusion of more vertebrae in the fixation was not associated with any untoward effect in any of the dogs.
5.10.7 Hemilaminectomy

Hemilaminectomy was performed in dogs of Group II for spinal cord decompression before application of fixation devices as recommended by Cook (1992). But, Bagley et al. (2000) had recommended realigning the vertebrae and not performing a hemilaminectomy in order to preserve as much of bone integrity as possible. The technique could be performed successfully in all cases using only rongeurs as reported by Voss and Montavon (2004). However, the use of pneumatic drill as suggested by Scott (1997) may have been helpful in reducing the time taken for surgery. The use of nerve hook helped to prevent accidental damage to the spinal nerves during hemilaminectomy in all dogs of Group II except one. The performance of hemilaminectomy in the left side in all cases as lateralization of spinal cord compression could not be made by myelography was in accordance with the report of McKee (1992) and Scott (1997). Both authors had reported the performance of hemilaminectomy in dogs with intervertebral disc disease routinely on the left side if lateralization of the spinal cord compression could not be made.

The extension of laminectomy half way into the vertebrae cranial and caudal to the site of spinal injury provided sufficient exposure of the compressed spinal cord. This helped clear visualization of the spinal cord and increased the accessibility of protruded disc material and fragments of bone pressing into and injuring the spinal cord.

The use of bone wax as suggested by Wheeler and Sharp (1994) helped control bleeding from the cancellous bone at the laminectomy site. The effective control of bleeding and the application of free fat graft at the hemilaminectomy defect as suggested by McKee (1992), Muir et al. (1995) and Scott (1997) may have prevented laminectomy membrane formation as none of the dogs of Group II had post-operative complications
suggestive of spinal cord or nerve root compression by laminectomy membrane during the study period.

5.10.8 Wound closure

The method adopted to appose the dissected muscles and the subcutaneous tissue was highly efficient in reducing dead space and promoting fast wound healing. The uncomplicated wound healing in all the dogs of Group I and II indicated the successful application of the technique in all animals.

5.10.9 Post-operative care

Seroma formation was a common finding in both surgical groups as extensive muscular dissection was involved for adequate exposure of the injured part of the vertebral column for realignment and implant fixation. In Group II, seroma formation was more than in Group I because more trauma to tissue was involved in the form of more extensive muscle dissection for the performance of hemilaminectomy. Flushing of the large seromas after drainage with normal saline helped to wash out tissue debris which would have predisposed to bacterial infection.

Ceftriaxone, a third generation cephalosporin, was found to be effective in preventing bacterial infection of the surgical site. The clearing of mild purulence of the seroma in two dogs of Group II by the addition of gentamicin to the flushing solution showed the efficacy of the drug in similar situations especially in the presence of cephalosporin antibiotics. Early resolution of the condition was a necessity to prevent extension of infection to the vertebrae or the spinal cord. The combination of gentamicin and cephalexin had been recommended for treatment of osteomyelitis by Bardet et al. (1983). The use of cephalosporin antibiotics in spinal surgery patients has been reported by Blass et al. (1988), Necas and Sedlakova (1999) and Rayward (2002).
Removal of urine from the LMN bladders was easy because of the reduced urethral sphincter tone in these cases. The UMN bladders were more difficult to drain as the sphincters were spastic and contracted preventing free outflow of urine. Avoidance of urethral catheterization in spite of this as recommended by Bagley *et al.* (2000) prevented iatrogenic cystitis in these patients.

Measures like turning the dogs as long as they were paraplegic every two to three hours and providing soft bedding as suggested by Bagley *et al.* (2000) were very useful methods for preventing the formation of or aggravating already existent decubital ulcers. Massaging and passive physiotherapy also prevented atrophy of muscles of the limb.

The presence of haemorrhagic gastroenteritis in one dog each of Group I and II at the time of presentation was possibly because of auto-sympathectomy due to spinal cord injury which increased the vagal tone leading to increased gastrointestinal secretions predisposing the gastrointestinal tract mucosa to ulceration and bleeding. Moore and Withrow (1982) noted that in contrast to man, the sympathetic outflow in dogs aroused diffusely from each of the thoracic and lumbar spinal segments, which made vagotonia less likely to occur. They noted that if vagotonia was a factor causing gastrointestinal haemorrhage in dogs, it might be related to the severity of the injury to the cord and not the location of the injury. They suggested that there might be a threshold beyond which haemorrhage would occur. The threshold might be reached by an insult to the gastrointestinal mucosa by factors like corticosteroid administration, stress of surgery or a severe neurological injury, but was more easily reached when a combination of factors occurred simultaneously. Both these dogs had been treated with corticosteroids and/or NSAIDs by local veterinarians before being presented to the College Hospital. Yovich *et al.* (1994) had reported that 3 out of 61 dogs with thoracolumbar disc protrusion had severe
haemorrhagic diarrhoea, of which two had received high dose of dexamethasone and one had received a combination of prednisolone and flunixin meglumine. The resolution of the condition in both dogs in the present study following medical treatment indicated the efficacy of the respective drugs in resolving severe cases of gastrointestinal ulceration. Timely initiation of treatment prevented worsening of the condition.

5.10.10 Post-operative complications

The paralysis of the abdominal wall was seen in one dog of Group II following accidental damage to the spinal nerve during hemilaminectomy. Bartels et al. (1983) also had noted that scoliosis and lateral abdominal wall weakness were the possible complications following spinal surgery by the dorsolateral muscle separation technique. Yovich et al. (1994) reported that 1 out of 61 dogs treated by modified lateral spinal decompression exhibited permanent scoliosis post-operatively. They opined that the dog probably suffered trauma to the lateral and medial branches of the thoracic and lumbar vertebral spinal nerves. However, in the present study the damage to the spinal nerve may not have been too severe as only abdominal wall paralysis was seen in the dog.

Trotter et al. (1988) had noted that severe post-operative spinal cord compression (constrictive fibrosis), caused by laminectomy membrane formation remained the major factor limiting the exposure and decompression achieved by laminectomy in the thoracolumbar region. However, none of the dogs in this study in which hemilaminectomy was performed showed clinical signs of hemilaminectomy membrane formation. This may have been because of the successful prevention of the membrane from being formed by the use of autogenous free fat graft as suggested by McKee (1992). Muir et al. (1995) also reported that they did not encounter complications associated with the formation of laminectomy membrane in dogs with
intervertebral disc disease treated by hemilaminectomy, when free fat grafts were placed at the laminectomy sites.

5.11 Non-surgical treatment

The procedure for ultrasound therapy was simple and could be performed in a short period of time. However, the requirement to present the patient on alternate days for the procedure was highly inconvenient for the owners. Moreover, the technique was not found to help in cases with instability of the vertebral column or severe compression of the spinal cord. Frequent transportation of the paraplegic patient may also cause further damage to the spinal cord due to the unstable vertebrae, further injuring the spinal cord. However, weekly administration of corticosteroid epidurally and daily administration of B complex vitamins orally was convenient for the owners. The results of the study indicate that non-surgical treatment of traumatic paraplegia may be adopted only in cases with a lesser degree of damage to the spinal cord having stable vertebral column as in dogs with intervertebral disc disease. A similar treatment protocol was successfully used in paraplegic dogs by Riaz (2004).

Medical treatment of traumatic posterior paralysis may not yield optimum results especially when there is instability of the vertebral column at the site of injury (Bagley et al., 2000; Lanz et al., 2000). Levine and Caywood (1984) reported a recurrence rate of 40 percent in dogs with intervertebral disc disease treated by medical treatment alone compared to a lower rate of recurrence when treated surgically. Prolonged treatment of dogs with spinal cord injury with corticosteroids is also said to inhibit the early adaptive and regenerative responses of the spinal cord (Coughlan, 1993). Lanz et al. (2000) recommended that when conservative management had to be tried in dogs with spinal injuries, corticosteroids should be discontinued after the initial neurotrauma protocol and neurological examination had to be performed twice a day.
for the first few days. Deterioration in neurological status warranted re-evaluation and possible surgical intervention. Munana et al. (2001) reported that all four cats with intervertebral disc disease treated surgically had excellent recovery while one out of two cats treated conservatively did not recover. Macias et al. (2002) reported that nearly 50 percent of the dogs with thoracolumbar disc disease that were treated non-surgically deteriorated within a year and had to be euthanized. Sanders et al. (2002b) reported that a tetraparetic dog with intervertebral disc protrusion into the spinal cord did not respond to conservative management. Kinzel et al. (2005) recommended that medical treatment of intervertebral disc disease in dogs be reserved for those patients whose owners decline surgical treatment.

Ultrasound therapy has not been recommended as a therapeutic means for traumatic posterior paralysis in animals. However, Steiss (2004) detailed the use of this technique for rehabilitation of dogs with neurological injuries. Thermal effect of the therapy was said to be the major indication for its use as ultrasound waves could increase tissue temperatures upto three to five centimeters deep to the skin. The technique may be useful only in cases of intervertebral disc disease with mild compression of the spinal cord and cannot have any beneficial effect in cases with vertebral instability or severe spinal cord compression.

5.12 Haematological studies

Griffiths (1982) did not list any possibility of abnormality in the blood picture in fractures and subluxations of the vertebral column in dogs. Many authors have reported that the results of a complete blood count were normal in dogs with spinal cord injury of different aetiology (Lemarie et al., 2000; Moore et al., 2000; Sanders et al., 2002b; Tidwell et al., 2002).
5.12.1 Haemoglobin (g/dl)

The mean values of haemoglobin ranged from 13.03 ± 0.27 to 13.47 ± 0.19, 13.15 ± 0.25 to 13.28 ± 0.20 and 13.03 ± 0.19 to 13.25 ± 0.14 in Group I, II and III respectively during the study period. The values were within the normal range in all stages of the different groups. This indicated that none of the dogs included in the study had any internal haemorrhage due to external trauma to cause significant reduction in the haemoglobin values and that neither paraplegia nor the type of treatment caused significant changes in haemoglobin values. Similar findings were recorded by Riaz (2004). One dog each of Group I and II which had haemorrhagic gastroenteritis on the day of presentation also had haemoglobin levels within the normal range. However, Moore and Withrow (1982) had opined that loss of blood into the gastrointestinal tract could probably cause anaemia in spinal patients.

5.12.2 Packed cell volume (PCV) (%)

The mean PCV values ranged from 39.83 ± 0.49 to 40.83 ± 0.48, 40.00 ± 0.59 to 40.50 ± 0.52 and 39.83 ± 0.46 to 40.25 ± 0.48 in Group I, II and III respectively during the study period. These values were also within the normal range in all stages of the different groups. This also indicated that none of the dogs included in the study had any internal haemorrhage due to external trauma to cause significant reduction in the PCV values and that neither paraplegia nor the type of treatment caused significant changes in PCV values. Similar findings were observed by Riaz (2004). In the dogs with haemorrhagic gastroenteritis also the values fell within the normal range.

5.12.3 Total erythrocyte count (TEC) (millions/cmm.)

The mean TEC values ranged from 5.85 ± 0.18 to 6.20 ± 0.07, 5.92 ± 0.13 to 6.03 ± 0.11 and 5.88 ± 0.12 to 6.07 ± 0.07 in Group I, II and III respectively during the study period. These values were also within the
normal range in all stages of the different groups. This also indicated that none of the dogs included in the study had any internal haemorrhage due to external trauma to cause significant reduction in the TEC values and that neither paraplegia nor the type of treatment caused significant changes in haemoglobin values. Riaz (2004) also did not record any change in the total erythrocyte count in paraplegic dogs. The values fell within the normal range in the two dogs included in the study with haemorrhagic gastroenteritis also.

5.12.4 Total leukocyte count (TLC) (thousands/cmm.)

The mean TLC values ranged from 16.42 ± 1.66 to 17.99 ± 1.24, 16.37 ± 1.80 to 20.52 ± 1.76 and 18.13 ± 0.88 to 20.81 ± 1.68 in Group I, II and III respectively during the study period. Even though there was no statistically significant difference (P<0.05) in the values within the different stages of each group or between the same stages of different groups, leukocytosis was seen on day of presentation in dogs of all three groups. In Group I and II, the mean TLC values fell to normal levels by the end of the study period. However, in Group III, the mean TLC values continued to increase till the end of the study period. The findings were in accordance with the statement of Wheeler and Sharp (1994) that stress leukogram, with leukocytosis was a common finding in spinal disorders in dogs. Dogs of all three groups had stress leukograms on the day of presentation. The mean TLC value fell to normal values as the dogs recovered neurologically in Group I and II. In Group III, the mean values went on increasing as most of the dogs continued to be non-ambulatory and under stress till the end of the study period. The increase in leukocytes in stress leukograms has also been indicated by Rebar et al. (2005).
5.12.5 Differential leukocyte count (DLC) (% of individual cells)

The mean neutrophil, lymphocyte, monocyte and eosinophil counts ranged from 71.17 ± 2.06 to 76.17 ± 2.06, 18.83 ± 2.06 to 23.67 ± 1.98, 3.33 ± 0.49 to 4.00 ± 0.37 and 1.33 ± 0.21 to 2.50 ± 0.43 respectively in Group I, 71.17 ± 2.27 to 76.83 ± 2.23, 17.67 ± 1.91 to 23.17 ± 2.33, 3.67 ± 0.21 to 4.17 ± 0.31 and 1.33 ± 0.21 to 1.83 ± 0.48 respectively in Group II; and 76.50 ± 2.20 to 79.17 ± 2.76, 15.33 ± 2.35 to 18.50 ± 2.20, 3.17 ± 0.17 to 4.00 ± 0.26 and 1.17 ± 0.17 to 2.00 ± 0.45 in Group III respectively. There was no statistically significant difference (P<0.05) in the mean values of the different cells between Group I and Group II at any stage during the study period. However, the mean values of neutrophils and lymphocytes of the dogs of Group III differed significantly (P<0.05) from those of Group I and II on days 45 and 60. This was because in Group I and II the increased number of neutrophils and reduced number of lymphocytes associated with stress leukograms of paraplegia reached normal levels by the end of the study period because of clinical recovery in majority of the dogs of these groups. However, in dogs of Group III only two dogs recovered completely and the non-ambulatory dogs continued to remain in a stressed state giving abnormally high values in the mean neutrophil counts and low values in the mean lymphocyte counts even at the end of the study period. The monocyte levels were within the normal range throughout the study period. The eosinophil levels were close to the lower limit of the normal range throughout the study period. The presence of stress leukograms during the paraplegic state was in accordance with the statement of Wheeler and Sharp (1994), and the picture of the individual types of white blood cells seen as part of the stress leukograms was in accordance with the description of the condition by Rebar et al. (2005).
5.13 Serum biochemistry

Many authors have reported that serum biochemistry profile was normal in dogs with spinal cord injury of different aetiology (Lemarie et al., 2000; Moore et al., 2000; Sanders et al., 2002b; Tidwell et al., 2002).

5.13.1 Calcium (mg/dl)

The mean values of calcium ranged from 9.73 ± 0.18 to 9.82 ± 0.25, 9.75 ± 0.20 to 9.87 ± 0.20 and 9.65 ± 0.22 to 9.75 ± 0.20 in Group I, II and III respectively during the study period. The values were found to be within the normal physiological range in all stages of the three groups. The absence of statistically significant difference (P<0.05) in the values obtained between the different days of study in the same group and the same stages of different groups indicated that the paraplegia or the type of treatment did not interfere with the calcium level in the blood. No significant variation in the serum calcium values during fracture healing has been observed by Singh et al. (1976) and Chaudhari (1997). No association between serum calcium and paraplegia has been mentioned by Simesen (1980) and Benjamin (2001). Riaz (2004) also did not observe any significant variation in the serum calcium values during the healing of vertebral fractures.

5.13.2 Phosphorus (mg/dl)

The mean serum phosphorus values ranged from 4.85 ± 0.26 to 4.98 ± 0.27, 4.75 ± 0.28 to 4.95 ± 0.30 and 4.42 ± 0.31 to 4.53 ± 0.25 in Group I, II and III respectively during the study period. The values were found to be within the normal physiological range in all stages of the three groups. The absence of statistically significant difference (P<0.05) in the values obtained between the different days of study in the same group and the same stages of different groups indicated that the paraplegia or the type of treatment did not interfere with the phosphorus level in the blood. Singh et al. (1976) and Chaudhari (1997) observed no
significant variation in the serum inorganic phosphorus values during fracture healing. No association between serum inorganic phosphorus and paraplegia has been mentioned by Simesen (1980) and Benjamin (2001). Similar observations were made by Riaz (2004) during the healing of vertebral fractures.

5.13.3 Potassium (mg/dl)

The mean values of potassium ranged from 4.40 ± 0.14 to 4.57 ± 0.14, 4.67 ± 0.22 to 4.72 ± 0.26 and 4.57 ± 0.18 to 4.63 ± 0.17 in Group I, II and III respectively during the study period. These values were also found to be within the normal physiological range in all stages of the three groups. The absence of statistically significant difference (P<0.05) in the values obtained between the different days of study in the same group and the same stages of different groups indicated that the paraplegia or the type of treatment did not interfere with the potassium level in the blood. Benjamin (2001) did not mention that changes in serum potassium were associated with paraplegia in animals.

5.13.4 Alkaline phosphatase (ALP) (U/L)

The mean values of ALP ranged from 118.30 ± 18.49 to 167.20 ± 35.48, 191.90 ± 56.50 to 259.60 ± 65.94 and 95.42 ± 20.96 to 175.10 ± 51.03 in Group I, II and III respectively during the study period. The values did not show any statistically significant variation (P<0.05) throughout the study period within each group. However, a non-significant increase in values was observed in the Group I and II till day 30 after which the values lowered till the end of the study period. This was because of the increased osteoblastic activity at the site of vertebral fractures during the healing period. The values fell after the 30th post-operative day because the stabilization provided by the fixation technique may have been helpful in achieving early healing of the fractures. But, in Group III there was a non-significant increase in the ALP values till day
15 after which there was a milder rise till the end of the study period. Because of the lack of surgical stabilization, the fractures would have been sites of continuous osteoblastic activity even at the end of the study period. Similar increase in the serum ALP values during the healing of vertebral fractures were observed by Riaz (2004).

However, the dogs included in the study were presented at different intervals from the time of spinal injury. This meant that the fracture sites were at different stages of osteoblastic activity. Moreover, in Group III, there were three dogs with intervertebral disc disease where no change in serum ALP values was expected. High degree of variation between individual dogs in the three different groups with respect to ALP values also made them less than ideal subjects for statistical comparison. These factors may have influenced in the mean values of ALP in this study to show non-significant increase, which was not in conformance with the observations of Singh et al. (1976), Chaudhari (1997) and Riaz (2004). The former authors had observed a significant rise in the serum ALP values during the healing of long bone fractures, while the latter had recorded significant increase in the value during the healing of vertebral fractures.

5.13.5 Aspartate aminotransferase (AST) (U/L)

The mean values of AST in all the three groups ranged from 41.37 ± 1.84 to 41.70 ± 1.84, 40.70 ± 1.65 to 40.98 ± 1.56 and 40.90 ± 1.85 to 41.25 ± 1.70 in Group I, II and III respectively during the study period. The values were within the normal physiological range throughout the study period and there was no statistically significant difference (P<0.05) between the values on different days of the same group or between the groups. This shows that neither paraplegia nor the treatment methods adopted caused any change of the AST values. The normal values on the 15th post-operative days in Groups I and II may indicate that even though extensive muscular dissection had to be performed, the
traumatized muscles healed fast preventing continued leakage of this intra-cytoplasmic muscular enzyme. Similar observations were made by Riaz (2004).

5.13.6 Alanine aminotransferase (ALT) (U/L)

The mean values of ALT in all the three groups ranged from 43.87 ± 3.12 to 44.10 ± 3.18, 45.22 ± 2.78 to 45.38 ± 2.94 and 42.93 ± 1.94 to 43.17 ± 2.00 in Group I, II and III respectively during the study period. The values were also within the normal physiological range throughout the study period and there was no statistically significant difference (P<0.05) between the values on different days of the same group or between the different groups. This shows that neither paraplegia nor the treatment methods adopted caused any change of the ALT values also. Similar conclusions were made by Riaz (2004).

5.14 Cerebrospinal fluid (CSF) analysis

No abnormalities were observed in the colour, clarity and cell type of any of the CSF samples. All these parameters were the same as those listed for normal dogs. Griffiths (1982) had stated that cerebrospinal fluid analysis was not usually performed for diagnostic purposes for traumatic injuries of the spinal cord like fracture/dislocation, traumatic disc, cord concussion and vertebral collapse.

In this study, the mean specific gravity, mean cell count (per µl) and mean total protein (mg/dl) in dogs of Group I were 1.004 ± 0.001, 3.33 ± 0.42 and 17.65 ± 0.76 respectively. In Group II, mean specific gravity, the mean cell count (per µl) and mean total protein (mg/dl) were 1.004 ± 0.001, 2.80 ± 0.58 and 17.87 ± 0.93 respectively. In Group III, the mean specific gravity, mean cell count (per µl) and mean total protein (mg/dl) were 1.004 ± 0.001, 2.83 ± 0.31 and 18.20 ± 0.45 respectively. The mean values of specific gravity, cell count and total protein content of the samples were also within the normal range in all groups. This may
have been due to the fact that the samples were collected from the cisterna magna. Since the CSF is formed in the ventricles of the brain and flows caudally through the subarachnoid space and gets absorbed through the arachnoid villi located caudally in the subarachnoid space, only those samples collected from the subarachnoid space behind the site of spinal cord injury may be expected to have changes in the parameters studied. Increased abnormalities in the cerebrospinal fluid from the lumbar cistern compared to that from the cerebellomedullary cistern due to the predominant caudal flow of cerebrospinal fluid from the brain to the terminal spinal cord have been reported by Indrieri et al. (1980) and Thomson et al. (1989, 1990). Bailey and Higgins (1985) also had found that statistically significant differences existed in the protein and white blood cell count in the cerebrospinal fluid from the cisterna magna and the lumbar cistern even in normal dogs. The levels of creatinine kinase and lactate dehydrogenase in the cerebrospinal fluid from the lumbar cistern were found to be significantly higher than that from the cisterna magna in dogs with thoracolumbar disc disease by Necas and Sedlakova (1999). Protein content and cytologic findings in the cerebrospinal fluid collected from the cisterna magna have been reported to be normal in osteosarcoma of the L₃, L₄ and L₅ vertebrae in a dog (Moore et al., 2000) and in cats with intervertebral disc disease (Munana et al., 2001).