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Evaluation of physiological, hematological, and biochemical changes in long bone fracture repair with external skeletal fixators in bovine

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Abstract

The present study was conducted to evaluate the physiological, hematological, and biochemical changes associated with long bone fracture repair in bovine calves treated with different types of external skeletal fixators. A total of 18 calves with long bone fractures were divided into three groups, each comprising six animals, and treated using linear, circular, and free-form external skeletal fixation techniques. Physiological parameters, hematological indices, and biochemical markers were assessed pre-operatively and at 15th, 30th, and 45th days post-operatively.

The results indicated no significant alterations in physiological parameters such as respiration rate, heart rate, and rectal temperature within and between groups. Hematological findings revealed significant changes in differential leukocyte counts, with a decrease in neutrophils and an increase in lymphocytes over the healing period, indicating a reduction in inflammation and progression of recovery. Biochemical analysis showed a gradual increase in serum calcium and phosphorus levels, along with elevated alkaline phosphatase activity during early healing stages, reflecting active bone formation and remodeling.

The study concludes that external skeletal fixation is an effective method for fracture management in bovine calves, with observable hematobiochemical changes corresponding to different phases of bone healing. These parameters can serve as reliable indicators for monitoring fracture repair and recovery.

Keywords: Long bone fracture, external skeletal fixator, bovine calves, physiological parameters

Introduction

A fracture is a break in the continuity of hard tissue. Bone heals through regeneration, unlike muscle, skin, and heart tissue, which form scars. The management of long bone fractures remains a significant challenge in large animals. The objective of fracture treatment is anatomic reduction and immobilization of fractured bone by external coaptation methods (Anderson *et al.*, 1994) [3], internal fixators and external fixator applications (Martens *et al.*, 1998, Vogel and Anderson, 2014) [8, 12]. External fixation effectively treats open and closed fractures, limb deformities, non-unions, and arthrodesis (Vogel and Anderson, 2014) [12]. The various changes viz., physiological, hematological and biological changes occurs during the fracture repair in preoperative and post-operative periods. The present study carried out to know the physiological, hematological and biological changes occurs in bovine calf that underwent long bone fracture repair by various external skeletal fixators.

Materials and Methods

The 18 bovine calves with long bone fracture were selected for the present study and divided in three groups. The each groups having six cases which treated with linear external skeletal fixation (group-I), circular external skeletal fixation (group-II) and free form external skeletal fixation (group-III). The physiological parameters assessed preoperatively and post operatively. Blood samples were obtained from the jugular vein using K₃EDTA vials both before and after the surgery at intervals of 15th, 30th, and 45th days and various parameters including hemoglobin (gm/dL), packed cell volume (%), total leukocyte count (10³ cells/cumm), total erythrocyte count (10⁶ cells/cumm), and the components of the Differential

Leukocyte Count (DLC) such as neutrophils (%), lymphocytes (%), eosinophils (%), and monocytes (%) were studied. A 7ml blood sample was drawn from the jugular vein into a clot activator tube. The serum was then separated, and biochemical parameters including serum calcium (mg/dL), serum phosphorus (mg/dL), and serum alkaline phosphatase (IU/L) were assessed both pre- and post-operatively on the 15th, 30th, and 45th days.

Results and Discussion

Physiological Parameters

In Group-I, mean of respiration rate per minutes was 21.00±1.24 pre operatively while post-operative it was 24.17±2.59 and in Group-II, mean of respiration rate per minutes was 27.17±1.85 pre operatively while post-operative it was 27.83±1.80, whereas, in Group-III, mean of respiration rate per minutes was 24.67±3.82 pre operatively while post-operative it was 20.17±1.42. The current study found no statistically significant alteration ($P > 0.05$) within groups during both the pre-operative and post-operative periods. While, in between groups significant ($P < 0.05$) difference was observed post-operatively in group-II and III whereas, no significant ($P > 0.05$) difference observed in group-I. This might be due to excitement during the recovery period from general anesthesia in calves. Similar to the study, Yadav *et al.* (2021a) [13] found a non-significant increase in respiratory rates on the first post-operative day in all animals, followed by a decrease from the third day in bovines treated for tibial fractures.

The mean of heart rate per minutes was 77.83±8.39 pre operatively while post-operative it was 75.17±9.20 in Group-I. In Group-II, mean of heart rate per minutes was 68.33±3.74 pre operatively while post-operative it was 68.00±4.48, whereas Group-III, mean of heart rate per minutes was 71.33±4.90 pre operatively while post-operative it was 67.00±6.81. The present study found no noteworthy ($P > 0.05$) alteration in mean value of heart rate within the groups or between the groups at pre and post-operative period. The present findings were in accordance with Das *et al.* (2020) [6] and Ajjodi *et al.* (2022) [2].

The mean value of rectal temperature in °F was 101.33±0.71 pre operatively while post-operative it was 100.63±0.44 in group-I. In Group-II, mean value of rectal temperature in °F was 101.70±0.52 pre operatively while post-operative it was 100.63±0.57, whereas in Group-III, mean value of rectal temperature in °F was 101.57±0.53 pre operatively while post-operative it was 100.33±0.21. The present study found no substantial ($P > 0.05$) difference in mean value of rectal temperature within the groups or between the groups at pre and post-operative periods. These might be due to administration of a non-steroidal anti-inflammatory drug at the time of preoperative preparation which reduce the temperature. The similar findings were observed by Prasad (2013) [10] and Das *et al.* (2020) [6].

Hematological Parameters

There were no significant difference observed in mean value of haemoglobin, packed cell volume, total erythrocytes count, and total leucocyte count on day 0, 15th, 30th and 45th post days, but in differential leucocytes count significant differences was observed in neutrophils and lymphocytes. The mean value of neutrophils on 0 day was 47.17±0.75 and on 15th, 30th and 45th post-operative days the values were 43.50±0.62, 40.83±0.17 and 38.83±0.48, respectively in group-I. The mean value of neutrophils on 0 day was 47.50±1.18 and on 15th, 30th and 45th post-operative days the values were 43.17±1.14, 40.50±0.62 and 37.83±0.75, respectively in group-II, whereas, mean value of neutrophils on 0 day was 48.67±0.76 and on 15th, 30th and 45th post-

operative days the values were 43.33±0.42, 40.67±0.56 and 36.83±0.75, respectively in group-III. In comparison between groups, there was no substantial ($P > 0.05$) differences in mean value of neutrophils at different time interval. While, in within the groups, mean value of neutrophils was significantly ($P < 0.05$) higher at 0 day as compared to 15th, 30th and 45th post-operative days in group-I and III. However, the mean value of neutrophils was significantly ($P < 0.05$) lower at 15th, 30th and 45th post-operative days in group-II as compared to 0 day. The higher the neutrophils count at the time of presentation of case might be due to extent of trauma that may leads the inflammation and decreasing counts indicating a reduction in inflammatory response allowing progressive fracture healing. These findings were in concurrence with the findings of Yadav *et al.* (2021a) [13] and Sravanti *et al.* (2022) [11].

On the 0 day, mean value of lymphocytes was 48.17±0.70 whereas, on the 15th, 30th and 45th post-operative days values were 51.83±0.48, 56.33±0.49 and 58.50±0.56, respectively in group-I. On the 0 day, mean value of lymphocytes was 47.83±1.08 whereas, on the 15th, 30th and 45th post-operative days values were 51.67±0.88, 55.33±0.8 and 58.17±0.83, respectively in group-II. The mean value of lymphocytes was 46.83±0.79 on day 0 whereas, on the 15th, 30th and 45th post-operative days values were 51.67±0.42, 55.50±0.76 and 59.83±0.60, respectively in group-III. In present study, no significant ($P > 0.05$) differences was found in mean value of lymphocytes between the groups at different time interval. The mean lymphocytes in within the groups was significantly ($P < 0.05$) higher at 15th, 30th and 45th post-operative days as compared to 0 days in group-I and III. While, non-significantly ($P < 0.05$) higher at 15th and 30th day and significantly ($P < 0.05$) higher at 45th post-operative days as compared to 0 day in group-II. This could be attributed to the fluctuation in neutrophil count, which initially increases after surgical intervention, prompting the production of immune-regulatory cytokines by macrophages. These cytokines are involved in activating adrenal axes and stimulating the production of glucocorticoids, which may result in the breakdown of lymphoid tissue and a rise in circulating lymphocytes. These findings were in accordance with those observed by Avasthi (2012) [5] and Sravanti *et al.* (2022) [11]. The no significant difference was observed in mean value of monocytes and eosinophils.

Biochemical Parameters

Serum Calcium

In group-I, the average serum calcium level on day 0 was 8.67±0.11, while on the 15th, 30th, and 45th postoperative days, the values were 9.38±0.32, 9.17±0.18, and 8.98±0.15, respectively. In group-II, the mean serum calcium level on day 0 was 8.62±0.25, and on the 15th, 30th, and 45th postoperative days, the values were 9.38±0.30, 9.07±0.18, and 8.72±0.24, respectively. In group-III, the average serum calcium on day 0 was 9.72±0.55 whereas, on the 15th, 30th and 45th post-operative days values were 10.32±0.55, 9.47±0.24 and 9.4±0.30, respectively. The current study found no significant ($P > 0.05$) differences in the mean serum calcium between the groups at different time intervals. The comparisons within the groups found level of serum calcium was non-significantly ($P > 0.05$) increased at 15th, 30th and 45th days as compared to 0 day in all the groups. The decreasing the serum calcium level on 30th post-operative days might be due to excessive calcium deposition at fracture site and increasing the level on 45th day as comparison to 0 day it may be due to remodeling phase. These findings were in concurrence with the findings Kumar *et al.* (2018) [7] and Prajapati (2021) [9].

Serum Phosphorus

The mean value of serum phosphorus in group-I on 0 day was 4.60 ± 0.49 and on 15th, 30th and 45th post-operative day's values were 6.33 ± 0.29 , 5.83 ± 0.12 and 5.68 ± 0.18 , respectively. The mean value of serum phosphorus in group-II on 0 day was 4.70 ± 0.27 and on 15th, 30th and 45th post-operative day's values were 5.97 ± 0.25 , 5.78 ± 0.19 and 5.67 ± 0.25 , respectively. The mean value of serum phosphorus in group-III on 0 day was 4.98 ± 0.52 and on 15th, 30th and 45th post-operative day's values were 6.37 ± 0.39 , 6.17 ± 0.31 and 6.5 ± 0.26 , respectively. The present investigation shows the mean serum phosphorus in between groups at 0, 15th and 30th days were non-significant ($P > 0.05$) but the values were significantly higher on 45th days in group-III as compared to group-I and II. These findings corroborated well with the findings of Prajapati (2014) [9]. The comparisons within the groups found serum phosphorus level significantly ($P < 0.05$) increased at 15th, 30th and 45th days as compared to 0 day but on 45th day values decreased non-significantly as compared to 15th and 30th post-operative days in group-I and III. While no significant differences were observed in group-II. Increasing serum phosphorus level on 15th, 30th and 45th day as compared to 0 day might be due to necrotic dissolution of cells at the site of fracture. These findings corroborated well with the findings of Prajapati (2021) [9] and Sravanti *et al.* (2022) [11].

Serum Alkaline Phosphatase

On the 0 day, the mean value of serum alkaline phosphatase in group-I was 142.67 ± 4.05 , while on the 15th, 30th and 45th post-operative days, it was 172.17 ± 7.22 , 144.17 ± 3.89 and 133.00 ± 2.25 respectively. On the 0 day, the mean value of serum alkaline phosphatase in group-II was 130.50 ± 1.75 , however on the 15th, 30th and 45th post-operative days, it was 152.17 ± 3.34 , 141.17 ± 2.85 and 120.67 ± 4.98 respectively. On the 0 day, the mean value of serum alkaline phosphatase in group-III was 129.50 ± 6.65 , although on the 15th, 30th and 45th post-operative days, it was 164.50 ± 6.25 , 145.67 ± 4.65 and 127.83 ± 2.09 respectively. The present study found the no significant differences in mean serum alkaline phosphatase in between the groups at different time intervals. The comparisons within the groups found the mean serum alkaline phosphatase in group -I significantly increased at 15th days and non-significantly increased at 30th days while non-significantly decreased on 45th days as compared to 0 days. In group-II and III, values significantly increased at 15th and 30th days while non-significantly decreasing at 45th post-operative days as compared to 0 days. Increased serum alkaline phosphatase levels indicate enhanced chondroblastic proliferation and formation of bones during bone healing. The destroyed periosteum is good source of alkaline phosphatase. Increased osteoblastic activity promotes normal fracture healing. Osteoblasts generate new tissue (bone matrix) and mineralize it and also produce a large amount of alkaline phosphatase which helps in bone healing. These findings were in congruence with the findings of Aithal *et al.* (1995) [1] and Athira *et al.* (2018) [4].

Conflict of Interest

Not available

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Not available

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