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Hemodynamic Instability of Femur with Closed Fractures in Children

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ABSTRACT

Background: This prospective study examines whether hypovolemic shock occurs in kids with traumatic solitary closed femur fractures. The common symptom ranges from minor to severe trauma in children and adolescents.

Methods: From September 20, 2015, to August 15, 2018, children with traumatic femoral fractures were the subject of prospective descriptive research. One hundred individuals were hospitalized at the Sulaimaniyah Emergency Hospital with isolated closed fractures of the femur in children. The goal was to rapidly fix the old criteria for blood transfusions that did not adequately indicate a replacement with actual blood requirements. Measurements were taken based on the children's clinical parameters, such as pulse rate, systolic blood pressure, respiratory rate, skin capillary refill time, and mental status, rather than hemoglobin or hematocrit concentration. Open fractures, bilateral fracture femur in children, and any fracture associated with trauma to the body organ as associated injury were all excluded.

Results: When compared to widely recognize normal vital sign readings, the 100 patients with these types of fractures who satisfied the study's inclusion criteria showed no signs of hemodynamic instability. The study excluded any patients with hemoglobin levels below 8.5 g/dl, equivalent vital signs between the two groups, and a 2-6% incidence of hemodynamic instability among numerous injured children with femoral fractures.

Conclusion: In children with traumatic solitary femoral fractures, there was no sign of hemodynamic instability. Early hemoglobin and hematocrit ratios were unreliable. They did not significantly change or increase at an abnormal rate. Isolated closed femoral fractures were confirmed to be hemodynamically stable based on vital sign measures in patients with femur bone fractures after ruling out bilateral femur fractures, concomitant damage, or individuals.

Keywords: *Hematocrit, Hemodynamic, Hemodilution, Fracture femur*

INTRODUCTION

Children with traumatic closed femoral fractures are at risk for hypovolemic shock, according to multidisciplinary orthopedic facilities. A variety of treatments were used to treat the trauma that regularly affects children and teenagers due to low- to high-intensity activity. These procedures include intramedullary nailing, plating and screws, external fixation, traction at home, traction followed by Spica casting, and immediate Spica casting. The middle third (diaphyseal) of the femur's shaft is the commonest place for fractures in children of all ages, peaking between the ages of two and five. Fractures in men are three times as common as in women. The most frequent cause of fractures in children under the age of five is falls.

For up to 72 hours following acute trauma hemorrhage, hematocrit does not adequately reflect the root cause of red blood cell mass reduction other than the hemodilution event that has been recognized. [1-3] Twenty percent of the entire blood volume is lost when a child's femur suffers an isolated fracture. Since hemodilution will distort the results, blood samples taken from all patients with isolated closed femur fractures in children were sent for testing of hemoglobin-hematocrit ratio. This testing revealed that the ratios were unreliable. However, since these children had isolated fractures of the femur, it is necessary to rely on the evaluation of vital indicators, such as the heart rate (beats/ min), blood pressure, heart rate, breathing rate, the time it takes for capillaries to refill, and mental state. [4]

Two percent of all fractures in the general population are femoral shaft fractures in children, with a frequency of about 20/100,000 per year. The patient's age, the nature of the fracture, the use of a Pavlik harness on children younger than six months old, intramedullary nailing, Spica casting, external fixation, and sub-muscular plating, are all possible choices of therapy. With the benefits of shorter hospital stays and earlier mobility, improvements in therapy utilizing various forms of fixation have also helped to boost the popularity of surgical treatment. [5-7] Of the nine patients examined by Kopp et al., five had a shock when they arrived at the causality hospital, while the other eight had stable general conditions. [8] All of the shock children had either multisystem injuries, such as bilateral femur fractures, or related injuries to other body systems. In the aforementioned investigation, most patients were brought back to life more quickly and then transferred for any necessary operations, regardless of when they occurred. These were verified following the elimination of any other injuries or bilateral femur fractures in children, and they were regarded as hemodynamically stable.

Keith et al. helped manage patients with bilateral femoral fractures or multisystem organ injuries. They represented a life-threatening emergency that needed to be addressed right away and fixed with stabilization as soon as the patient's health permitted. [9] Before establishing a conclusive view, further information must be examined. Early stabilization is mandatory, but definitive treatment is still necessary. [10] According to a study by [11], the mortality rate for bilateral femoral shaft fractures can approach 16%. By providing prompt care for these patients, any deaths in this group of patients were prevented and reduced the rate of morbidity. Subsequent hemodynamic stability was enhanced by adequate repair and early stabilization of femoral fractures after isolated fractures. After initial resuscitation, these fracture types require early fixing with intramedullary nailing for adequate stabilization. [13]

In the Department of Orthopaedic, pediatric closed femoral shaft fractures can be fixed externally, internally with open reduction, or internally with closed reduction and external fixation. Children who have bilateral femur fractures are properly evaluated when they are admitted to hospitals for treatment. Children under the age of five who have closed femoral shaft fractures are typically treated conservatively. However, children beyond the age of 11 were treated with internal fixation in addition to open reduction, as is evident in Table 1 and Figure 1. The considerable blood loss in children who have closed femoral fractures is less visible when it comes to hypovolemic shock. [14] The most frequent causes of trauma are falls and motorcycle accidents. Amazingly, they account for two-thirds of devastating injuries in older kids. Up to 80% of femur fractures in children under the age of five arise from non-injury types of fractures. Falling to the ground appears to be a more common cause of injury in younger children. When opposed to unintentional traumatic injuries that cause spiraling, transverse femur fractures in younger children are an excellent predictor of non-traumatic injuries. [15]

Identification and classification of fractures can be done according to their nature, location, stability, and whether they are closed or open. Another categorization for femur fractures includes oblique short or long, comminuted, transverse, and spiral. The exact location of a femur fracture must be determined because the direction in which fragments will be displaced from muscles inserted into the bone will depend on the force acting on the fragments themselves.

Table 1 shows the angles and displacements in various directions as well as age-related shortening factors in children for this type of fracture. Transverse fractures are thought to be stable and a component of either a short or long oblique. Comminuted or segmental fractures, however, are considered unstable. These closed-type femur fractures do not include compound or open fractures. Several factors affect how a closed femur fracture is treated, including the child's age, fracture type, mechanism of injury, and body weight. [16] Some management options for managing femur fracture include traction, followed by Spica casting, Pavlik harness, instantaneous Spica casting, Spica casting containing traction pin, and home traction all resulting in a satisfactory outcome. Other techniques include sub-muscular plating, rigid nailing, rigid intra-medullary nailing, and external fixation. [16]

All children with closed femur fractures should have their hematological status evaluated and tested, but healthy kid patients do not need to undergo cross-matching because they do not experience hypotension or a decline in the hemoglobin-hematocrit ratio. When a youngster suffers from a single, closed femur fracture, dynamic instability and a sharp decline in the hematocrit-hemoglobin ratio are uncommon. If so, the expert checking for organ trauma or concomitant injuries must be informed. [17]

The present study was aimed at investigating femoral hemodynamic instability in closed fractures in children.

MATERIALS AND METHODS

Ethical approval

This is a cross-sectional study. Samples were randomly split into two groups. The Sulaimani University School of Medicine's Ethical Committee gave its approval to the research procedure. Each participant gave his or her written informed consent before being enrolled in the study. The study was conducted following the Declaration of Helsinki and the World Medical Association's Code of Ethics for experiments involving human subjects.

Study population

From 20 September 2015 to 15 August 2018, 100 patients with single femoral fractures in children were transferred to Sulaymaniyah Emergency Hospital as part of a prospective descriptive study approved by the IBR of Sulaimani University. The reason for admission was to rapidly correct the old criteria for blood transfusions that did not adequately indicate a replacement with actual blood requirements. Rather than relying on hemoglobin or hematocrit levels, the clinical parameters of the children, which include their mental status, respiration rate, skin capillary refill time, pulse rate, and systolic blood pressure were considered.

Evaluation of fluid and blood transfusions

The effectiveness of fluid and blood transfusions was assessed following patient needs. Hematocrit and hemoglobin readings were acquired three days following the fractures, first and last. These initial causes, though, are distinct. from hemodilution itself. The body reactions that cause hemodilution to occur earlier in the post-trauma period were not significantly different from the normal range, thus they serve as exclusion criteria.

Inclusion criteria

All kids who were admitted to the emergency ward of the casualty hospital in Sulaimaniyah City. These subjects were recruited based on isolated, closed femoral fractures in young patients. Within four hours of the incident, a comprehensive examination of vital signs was ready with the definitive finding of a single, closed femoral fracture.

Exclusion criteria

Include birth injuries (child abuse), femur fractures treated by elective means when not immediately life-threatening, children who appear more than 24 hours late, predisposing variables to decrease bone mineralization brought on by spasticity or muscle contracture, inadequate bone formation, a slipping capital femoral epiphysis, a child who has bilateral femur fractures or complex femur fractures, as

well as any child who has presented with an accompanying injury (other parts of the body or organs).

Depending on the criteria for pediatric femur fractures, age variables, the degree of angle displacement, and the fracture's reduction in length relative to a normal fracture, as shown in Figure 1 and Table 1, respectively. The clinical images in Table 2 depicting predicted blood loss from diverse traumatized patients are visible for each volume and percentage. During the methodical processing assessment of the young patient with a broken femur, the medical images indicating anticipated blood loss from conservative and surgical care approaches were dependent on the clinical pictures (Table 1).

TABLE 1: Fractured femur in children and criteria for the treatment depending on age-deformity and by conservative surgery[15,27]

Age	Angles Varus/ Valgus (degrees)	Anterior/ Posterior (degrees)	Shortening(mm)	Orthopedic treatment options
Birthto2year	30	30	15	Pavlikharness Immediate Spicacast
2–5year	15	20	20	Immediate Spicacast Traction→ Spicacast
5-11year	10	15	15	Flexible intramedullary nailing
11years-skeletalmaturity	5	10	10	Rigid trochantericentry nailing Sub-muscular plating Flexible intramedullary nail (onlyif<50kg)

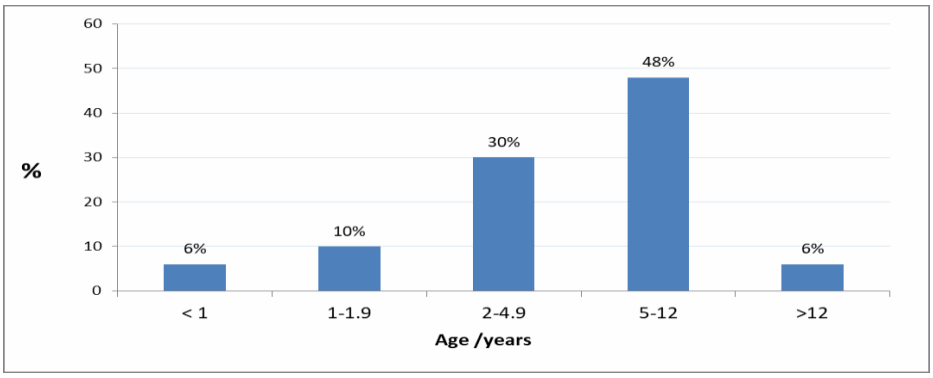

FIGURE 1: Age of more commonly affected child age with a fractured femur

TABLE 2: Estimation of blood loss with clinical signs from the different sites of the body during injuries (Clinical Criteria)

Volume lost in ml	Volume lost in Percentage %	Clinical Sign
500 <0.5liters	10	None, occasionally vasovagal Syncope/Closed fracture (femurin Children)
1000/ 0.5-1liters	20	At rest may be no clinical evidence of volume loss; as light postural drop in blood pressure may be seen; tachycardia with exercise (Closed Fracture Femurin Adult)
1500/1-2liters	30	Resting supine blood pressure and pulse may be normal; neck veins flat when supine; postural hypotenion. (Hemothorax)

2000/2-3 liters	40	Central venous pressure when, cardiacoutputsystolic blood pressure below normal even when supine and at rest; air hunger, cold clammy skin, tachycardia. (Intra-abdominal Injuries)
2500/2-3 liters	50	Signs of shock; tachycardia, hypotension, oliguria, drowsiness, or comma (Open Fracture Pelvis).

The amount of blood lost per milliliter was determined following the clinical indication of blood loss at a particular spot on the body. The clinical criteria presented in Tables 2 and 3, as well as the amount of blood loss, were used to explain why adult patients with closed, isolated femur fractures were more likely to experience hemodynamic instability than children. According to worldwide standards for these types of fractures, a child's blood loss must be less than 500 ml. Although adults may present at rest with no clinical indication of volume loss, a minor postural drop in blood pressure might be noticed, and tachycardia with activity. The clinical symptom in children is nonexistent or only sometimes occurs with vasovagal syncope. Blood samples from each patient with an isolated closed femur fracture in children were sent for hemoglobin-hematocrit ratio. The ratio of women to men is 44% to 56%. Evaluation of the vital signs of mental status, capillary refilling times, blood pressure, and respiration rate, for these fractures, are presented in Table 3 and Figure 2.

TABLE 3: Clinical criteria of the fractured femurin children

Age	Freq.	VS 1	R.	VS2	R.	VS3	R	SC in Second (S)	R, in Second (S)
<1 year	6%	102(82-120)	70-90	32(24-48)	30-40	148(90-150)	110-160	2.2-3.0 s	2-3 s
1-1.9	10%	110(100-130)	80-95	31(20-48)	25-35	150(92-179)	100-150	1.8-2.4 s	1.5-2.0 s
2-4.9	30%	110(80-140)	80-100	28(16-42)	25-30	120(88-160)	95-140	1.9-2.2 s	1.6-2.0 s
5-12	48%	110(80-140)	90-100	22(16-40)	20-25	101(68-132)	80-120	1.7-2.3 s	1.6-2.0 s
>12	6%	120(80-145)	100-120	22(12-30)	15-20	92(44-140)	60-110	1.6-2.1 s	1.5-2.0 s
VS 1: Vital Sign (Pulse Rate) Study Results; R: Recommended; VS2: Vital Sign Respiratory Rate) Study Results; VS3: Vital Sign (Blood Pressure) Study Results; SC: Skin Capillary(Refilling Study Results)									

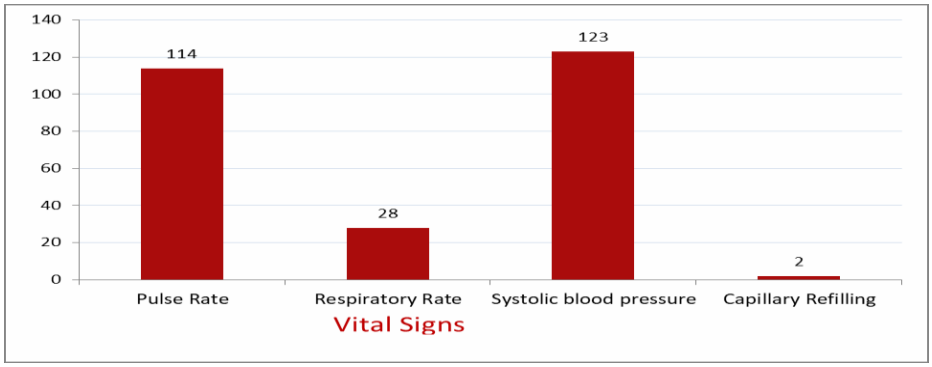

FIGURE 2: Mean vital signs of affected children with a fractured femur

Procedure

To document the existence or not experiencing hypovolemic shock, clinical parameters were compiled. These requirements must adhere to international norms. Pulse rate, systolic blood pressure, respiration rate, skin capillary refilling time, and mental state are among the parameters. Patients who met the exclusion criteria for mental instability were excluded from all age groups.

Statistical analysis

Statistical analysis of data was conducted using the statistical package for social sciences (SPSS; version 25.0; Armonk, NY, IBM Corp, USA) for Windows. Independent student T-tests were employed in the statistical analysis of numerical data to compare the variations between two means, which were then presented as a mean + standard deviation. The Independent T-test was used to compare two means after continuous data were transformed into means + standard deviations. At a threshold of <0.05, the p-value was considered statistically significant.

RESULTS

When compared to widely recognize normal vital sign values, none of the 100 patients who satisfied the study's inclusion criteria showed signs of hemodynamic instability. Figure 1 shows the age group of 5 to 12 years as being the most afflicted by fractures of the femur. There was no significant difference between patients who received a blood transfusion or fluid bolus and those who did not, as highlighted in Table 4 and illustrated in Figures 2 and 3. Values for hematocrit and hemoglobin did not reduce or increase. When the vital signs of the patients in this study were compared to those of the other patients, the patients who did not receive a fluid bolus presented with an isolated femur fracture in children. In the present investigation, 40% of the individuals received a fluid bolus even though they showed no clinical symptoms of hemodynamic instability. Based on a preliminary clinical assessment of the patients, and the fact that their hemoglobin and hematocrit ratio remained constant, no patients with femur fractures needed blood transfusions. There were no participants who had hemoglobin levels below 8.5 g/dl.

TABLE 4: Patients receiving or not receiving fluid or blood

Fractured femur receiving or not receiving (fluid or blood)	Patients Number 100	Frequency
Receiving fluid	26	26%
Receiving indicated blood	Out from study	2% were excluded from the study
Receiving non-indicated blood	Out from study	24% were excluded from the study
Not Receiving blood	74	74%

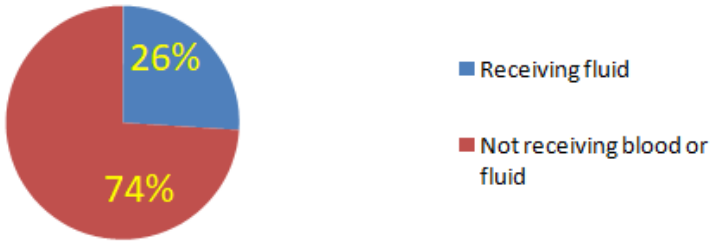

FIGURE 3: Percentage of patients receiving or not receiving fluid or blood

The vital signs were comparable across the two groups, but the study eliminated numerous injured children with femoral fractures due to a 2-6% frequency of hemodynamic instability. If

hemodynamic instability is apparent, another source of the bleeding must be found. Internationally recognized standards for measuring hypovolemic shock were applied in this investigation. There is still inter-observer variability in the impression of hypervolemia and the choice of fluid bolus resuscitation, as shown in Table 4 and Figure 3. One of the more sensitive signs of hypervolemia, tachycardia, may also be a sign of concurrent anxiety or pain in a kid, clouding the overall assessment of the child's hypervolemia condition.

Table 5 illustrates the treatment of these fractures based on the child's age. Twenty-two (22) patients between the ages of newborn and five years were admitted to the emergency hospital. Ninety-seven percent (97%) of the participants (21 patients out of 22) had conservative care, while 3% underwent surgical reduction and fixation. As stated in Table 1, these were severely out of criterion (angles and shortening acceptable criteria). The child age group of 6 to 10 years old consisted of 24 patients; 65% (16 out of 24 patients) of them received conservative treatment, the majority of whom had non-displaced fractures of the femur. In contrast, 35% (8 out of 24 patients) underwent surgery for displaced unstable fractures of the femur that did not meet acceptance criteria. However, children over the age of 11 (54 patients out of 100) confirmed the results in Table 5 and Figure 4 when 77% (42 patients) were treated surgically using different implants for fixing (intramedullary flexible nailing, rigid trochanteric entry nailing, and sub-muscular plating with screws). The results are highlighted in Table 4 and Figure 3. Children receiving indicated blood and those receiving non-indicated blood transfusions were excluded from the study because they belonged to a group of injured kids who had injuries other than fracture femur trauma. However, there were no blood transfusions given for solitary femur fractures. One hundred patients made up the study's total number of participants (74 patients were not receiving any fluid or blood, in addition to 26 patients who were).

TABLE 5: Fractured femur principle of management

Age	Conservative Treatment (%)	Conservative Treatment No. of Patients	Surgical Treatment (%)	Surgical Treatment
Birth to 5years (22patients/100)	97%	21	3%	1
6-10year (24patients/100)	65%	16	35%	8
11years (54patients/100)	23%	12	77%	42

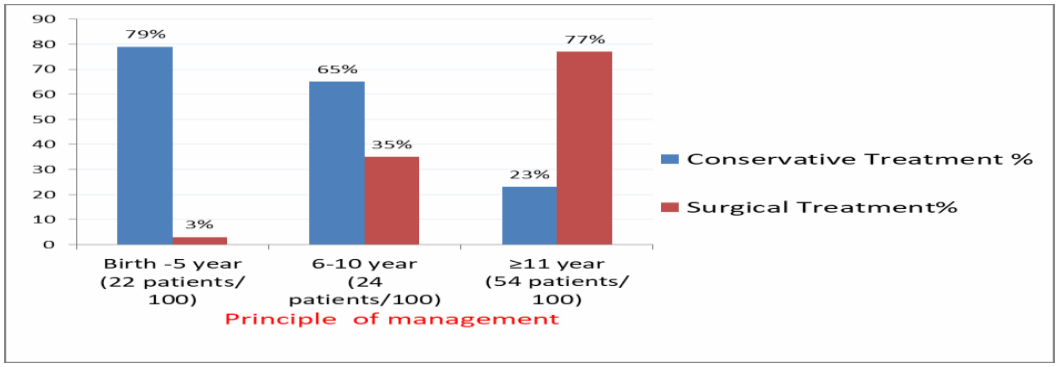

FIGURE 4: Management principles of surgical/conservative affected children with fractured femur according to age percentage

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Corresponding to mean vital signs of pediatric isolated femoral fractures, no clinical criteria were found for blood transfusion requirements as presented in Tables 4, 6, and Figure 3. Additionally, every aspect indicates that blood loss was 10% or less of the body's total volume (less than 500 ml of loss). Tables 2, 3, and 4, as well as Figure 3 all support maintenance of all other vital functions within normal limits, and the absence of any symptoms associated with vasovagal syncope.

TABLE 6: Vital signs (Mean- Standard Deviation)

Vital Signs	Mean	Standard Deviation
Pulse Rate	114	7
Respiratory Rate	28	5
Systolic blood pressure	123	22
Capillary Refilling	2	0
Mental state	Mentally stable	

DISCUSSION

The most frequent long bone injury in youngsters is a fractured femur. The focus of treatment is the child's age, as measured by bone age, as well as the child's size, which affected the treatment plan. The surgical experience and regional practice trends may influence the management option. In the majority of situations, conservative management applied the key concepts. The current practice, however, is focused on surgical fixation for reasons other than just early mobilization and a reduced length of stay. [18, 19] The results of the present study support the fact that age continues to have a significant effect on the decision to use a conservative or surgical therapy strategy. Children's shaft femur fracture care is still debatable, despite the availability of multiple treatment approaches that employ various techniques according to the guidelines of the American Academy of Orthopaedic Surgeons published in 2010. For children aged 5 to 11, intramedullary elastic nailing is recommended as the preferred treatment. Depending on the child's weight and bone age, different facilities may treat those age groups with hard nails, however, some employ non-operative care for the lower age groups and locked intramedullary nailing for the older. The sub-muscular plating, rigid trochanteric entrance nailing, and flexible intramedullary nailing were all reviewed by the American Academy as therapy choices for kids between the ages of 11 and skeletal maturity. The therapy regimen for pediatric femur fractures includes for kids aged 6 months to 5 years (with a 2 cm shortening), early Spica casting or traction with delayed Spica casting is recommended. [20, 21]. The results in the selection of treatment concepts presented in Table 7 and Figure 4 validated these management plans.

In comparison to individuals with femoral fractures that were isolated, patients with additional trauma showed significantly lower levels of hemoglobin and hematocrit, according to the findings. If a child with a femur fracture has a reduced hematocrit and/or hemoglobin content, the probability of additional traumatic injuries should be taken into account. [22] The results of the present study indicate that infants with solitary femur fractures are hemodynamically stable and do not require blood transfusions. Initially, the hemoglobin hematocrit was normal, and later on, only associated damage to other organs or bilateral femur fractures required blood transfusions. Femur fractures must be investigated in-depth during a physical examination, along with any related injured body parts. Rarely can an isolated femoral fracture cause hypotension. High-velocity automotive injuries are connected with Waddell's triad of femoral fracture, intra-abdominal or intrathoracic injury, and head injury. To facilitate overall care, a significant number of trauma patients admitted to Ugandan teaching hospitals' Causality and Traumatic Departments between December 2016 and June 2017 needed their femoral shaft fractures stabilized right away. This study concentrated on injuries that resulted in both

brain injury and vascular disturbance. This finding is in agreement with the results in this study of children with excluded femur fractures linked with open or compound fractures that result in bleeding as well as hypotension-related symptoms. [23] These findings revealed that children's solitary femur fractures are hemodynamically stable and do not require blood transfusions.

All kids who had compound fractures, other injuries to bodily organs, or concomitant trauma were disqualified from the trial. For healthy patients with isolated closed fractures of the femoral shaft, it is not advised to undertake normal laboratory tests or a cross-match because there is no evidence that these patients would develop hypotension or significant reductions in hematocrit. Patients who were observed in the orthopedics and rehabilitation department of a casualty hospital in the USA had hemodynamic stability. It is crucial to perform a thorough evaluation of the patient's circulatory and neurological systems in the affected limb. Vascular injuries have a reported incidence of 0.1 to 2% but are less likely to develop in this group of individuals with closed femur fractures. [24] In the present study, there was no discernible change between those who received a fluid bolus and those who did not, initial vital signs, as shown in Table 6. Children with closed femur fractures did not have lower hemoglobin or hematocrit values. This finding supports the result of the present study about isolated femur fractures in children with hemodynamic stability who did not require blood transfusions and whose hemoglobin-hematocrit levels were initially and afterward normal.

CONCLUSION

In children with traumatic solitary femoral fractures, there was no sign of hemodynamic instability. Early hemoglobin and hematocrit ratios were unreliable in the long run. They did not considerably drop or change to an abnormal pace. Isolated closed femoral fractures were confirmed to be hemodynamically stable based on vital sign measures in patients with femur bone fractures after ruling out bilateral femur fractures, concomitant damage, or individuals with complex fractures.

Authors' Contributions

The article has only single author who did everything.

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Institutional Review Board Statement

Not applicable.

Informed Consent Statement

Informed consent was obtained from all subjects involved in the study.

Data Availability Statement

Not applicable.

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CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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