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A Systematic Review

Can Trauma with Isolated Femur Shaft Fracture Injury Cause Clinicalhypotension? A Systematic Review

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Abstract:

Background: Closed isolated femur shaft fracture usually results from high energy trauma and traditionally assumed to have potential to cause hypotension that we rarely see in clinical practice. We wanted to find literature evidence of association between isolated closed femur shaft fracture and hypotension.

Methods: Literature was searched on PubMed, Ovid databases and google scholar website. Hand-searching from references of the articles obtained. All the articles addressing this issue dating from 1955 to 2023 were included in this systematic review.

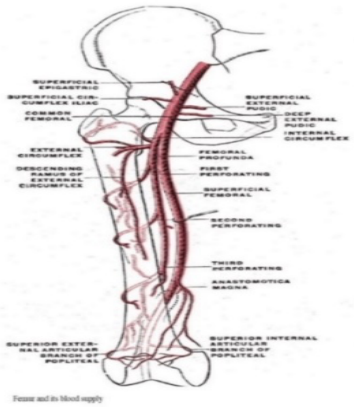
Results: Overall, 13 articles were found that are directly or indirectly concerned about association of femur shaft fracture and hypotension. Out of which, 6 articles are directly related to isolated femur shaft fractures sustained in children or adults. 2 studies indirectly estimated high blood loss pattern with femur shaft fracture, but 5 studies that directly studied hypotension with isolated femur fractures in more than 500 patients, P values of these studies suggest isolated femur shaft fractures don't cause hypotension.

Conclusion: The available evidence from the studies that actually studied incidence of clinical hypotension in isolated femur shaft fractures show closed isolated femur shaft fractures rarely cause clinical hypotension.

Keywords: Hypotension, Isolated Closed Femur Shaft Fracture, Skeletal Trauma.

Introduction

Trauma usually involves a musculoskeletal injury in-isolation or together with other organ injury. Hypotension is a significant risk factor associated with trauma related morbidity and mortality. Commonest cause of hypotension associated withmusculoskeletal trauma is blood loss, either from an internal or from an external source. Fractures involving femur shaft are usually high energy injuries such as motor vehicle accidents or fall from significant height. Anatomically femur has rich blood supply and major blood vessels running along its shaft and femur also has large soft tissue envelope around it with potential spaces to accommodate large amounts of fluid.



Blood supply of femur

(Adapted from Wikipedia: Case courtesy of Craig Hacking, Radiopaedia.org rID:92569.)

While there is evidence of hemorrhagic shock associated with open femur shaft fractures [1], that association is not clear in simple isolated femur fractures as there is not enough literature available.

It is most often the low systolic blood pressure that gets the most attention of treating emergency physician although actual hemorrhagic shock signs begin before the fall of systolic blood pressure. Even in the scenario of low systolic blood pressure, treating medical personnel may be misled by grossly deformed thigh fracture leading to erroneous assumption of it as the cause of hypotension.

Aim of the study:

Is to evaluateall theavailabledirect or indirect evidence in literature related to isolated femur shaft fracture and its association with hemorrhagic shock and draw inference whether isolated fracture of femur shaft actually causes clinical hypotension.

Methods of Literature sources and Search strategy used:

Articles used in this review were obtained from MEDLINE search using PubMed, Ovid database, google scholar and hand-searching from references of the available articles.PubMed search strategy involved using terms “femur shaft fractures” and “hypotension”, “hemorrhagic shock”, “femur”,” diaphysis”, “fractures”, randomized control trials, randomized, case control, observational and cohort studies. Terms were combined using AND / OR operators. Searches were rerun in various combinations of the above and combined altogether finally. Search resulted in only handful of relevant articles on this issue in questionandafter screening abstracts, were finally selected.

Background for the assumption of isolated femur shaft fracture and its’ association with hypotension:

Traditionally, it was thought femur shaft fractures are associated with significant internal bleeding. ATLS manual mentions femur shaft isolated alone can have up to 1500 ml of internal blood loss that corresponds to class II of acute hemorrhagic shock of American college of surgeons’ hemorrhagic shock classification category, characterized by tachycardia and decreased pulse pressure. Actual fall in systolic blood pressure starts from class III onwards in a healthy young person. [2]. Even though this classification may still underestimate the clinical reality of hemorrhagic shock [3], it is most widely used none the less.

Table 1

American college of surgeons’ hemorrhagic shock classification from ATLS manual				
Class	I	II	III	IV
Blood volume loss	Up to 750 ml	750- 1500 ml	1500 -2000 ml	> 2000 ml
Systolic blood pressure	normal	normal	decreased	decreased

In case of closed isolated femur shaft fractures, maximum amount of internal blood loss is estimated as 1200ml to 1276 mlbyseveral authors. But this assumption is mostly indirect evidence as in studies by Clark et al and Lieurance et al etc. Study by Clark et al [4] involvedmeasurements of fluid displacement and thigh girth estimated photographically to estimate leg swelling after trauma as an indirect indicator of amount of internal bleeding followed by corroboration with red cell volume volumes orhemoglobin levels done in the same patients. Study by Lieurance et al also indirectly calculated blood loss usingchanges in hemoglobin and hematocrit values in determining blood transfusion requirements for trauma victims [5].

Contradictory literature evidence to previous assumptions:

1. **Literature of blood transfusion rates in femur shaft fractures**

Callahan et al [6], retrospectively studied organ injury adjusted transfusion rates in trauma involving femur shaft fractures with or without solid organ injuryat a level-1 trauma center over 3 years period, suggests that clinical blood loss is actually less than generally assumed and found no difference in blood transfusion rates in isolated or solid organ injury associated with femur shaft fractures.According to this paper, transfusion required for blood loss should not be implied due to the presence of fractures or associated solid organ injuries alone. There was no emergency indication for blood transfusion found for subgroup of isolated femurshaft fractures in a retrospective study of 7-year duration done at an adult trauma center by Wertheimer et al [7]. Summary of the blood transfusion studies with corresponding p-values, is given in Table 2.

None of the patients that received transfusion needed blood transfusion within 4 hours of admission and either hemoglobin levels at the time of admission or surgeon’s preference was the indication for the transfusions done.According to them, since there was no pattern of increased blood transfusions noted,in isolated femur shaft fractures, one shouldactively search for other potentialcauses of hypotension.

Table 2

Study of transfusion rates among femur fractures in comparison to total study group with or without solid organ injury		
Percentage		P value
Callahan et al 2016 Transfusion rates among femur fractures with or without solid organ injuries	All femur 15.6 %	<0.001 (no statistically significant difference between isolated femur group with or without at least one solid organ injury)
	Femur with solid organ injury 15.4 %	1.000
Study of transfusion rates in femur shaft fractures versus femur extremity fractures		
Wertheimer et al 2018	36 %	0.08

2. Literature of clinical hypotension in femur shaft fractures

Most often bilateral femur fractures may have hypotension but that also is most likely as a result of other injuries in the body or due to pre-existing low cardiovascular reserve. In case of bilateral fractures mortality was significantly high as there is an80% association with chest, abdominal or head injuries, pointing towards severe mode of injury [1, 8]. Risk based approach to bilateral femoral fractures deals with this problem of concomitant injury contributors of increased mortality [9].

But unless, it is bilateral, open fracture or associated with other source of blood loss or pre-existing co-morbidities, isolated femur shaft fracture rarely causes clinical hypotension.[10].

Ostrum et al [11], in a retrospective study, investigated the relationship between hypotensive shock and isolated or other fracture associated femur shaft fractures of 100 patients. Other potentially hypotension-causing injuries were excluded in this study. They found no incidence of class III shock in these 100 patients. Ostrum et al even advised it is the responsibility of treating trauma surgeon to rule out other source of bleeding in the scenario of hypotension associated with isolated femur fracture.

In a 20-year period retrospective analysis study by Mitchnik et al [12], isolated femur shaft fractures cohort treated by Israeli defense force teams, has only 8.5% incidence of severe shock. Open fractures constituted 72.7% of these fractures resulting from motor vehicle accidents, gunshot wounds and explosion injuries. This whole cohort is actually from severe modes of injury accounting for presence of severe shock overall. Their multivariate logistic regression analysis shows, link between odds of having severe shock with presence of concomitant injuries. Their observation wasshock is rarely present with a primary femur shaft fracture.

Retrospective study of 187 children with closed femoral fractures at a New York hospital by Barlow et al [13],over a period of 15 years showed no hemodynamic abnormalities before or after surgery. Some of them received blood transfusion during surgery for debridement for compound fractures or during surgical fixation of the fracture. Lynch et al reported that none of isolated femur shaft fractures in the children they studied, had hemodynamic instability [14]. Alkhuzai[15]prospectively studied femur shaft fractures in 100 Ugandan children over 3-year period for association with hemodynamic instability. He found no association unless there were severe concomitant injuries.

Summary of the studies of incidence of ATLS class III clinical hypotension in isolated femur shaft fractures, is given in Table 3

Table 3

Studies isolated femur shaft fracture versus clinical hypotension		
	Isolated femur shaft fracture	ATLS Class III shock %
Barlow et al 1987	187 children	0
Ostrum et al 1993	100 adults	0
Lynch et al 1996	111 children	0
Alkhuzai 2021	100 children	0
Mitchnik et al 2022	129 adults (high energy and open injuries were included)	8.5

Discussion

Pre-existing assumptions about hypotension occurring with femur shaft fractures particularly that of the isolated ones, are lacking in supportive evidence at best. This preconception may have been due to frequent confounding variables that can actually cause shock are associated with bilateral femoral shaft fracture due to high energy trauma resulting in increased hypotension and mortality rates. High incidence of acute respiratory distress syndrome was reported by Giannoudis et al in

patients with bilateral femur shaft fractures [16]. They reported that multiple injuries were always present in the patients included in the study. Kobbe et alopined that increased mortality is associated undeniably with bilateral femur fractures and one should exercise extra caution in managing such patients [17]. The risk-adapted approach to deal with femur fractures that involves injury severity scores based on data from German registry of trauma, actually resulted in lessened mortality rates [9]. In general, the increased mortality rates previously assumed to be associated with bilateral femur fractures seem to have come down as examined by O'Toole et al [18]. This trend seems to be in line with the increased safety measures adapted by motor vehicle manufacturers over this periodof time.This also further corroborates the thinking that it is associated injuries due to severe mode of injury rather than femur fractures that were actual contributors for high mortality rates andincidence of hypotension.Naqvi et al [19] reported no mortality associated with bilateral femur shaft fractures resulting from high energy injury mechanisms.

In the study by Clark et al [4] that indirectly estimated blood loss using thigh girth, those measurements could be affected by significant edema from muscle or tissue trauma associated with femur fracture as it is usually high energy injury. Study by Lieurance et al [5] that studiedtransfusion incidence in isolated femur shaft fractures at university of Arizona medical center over a period from 1985 to 1990, also is indirect evidence at best because of confounding by various factors such as internal fluid shifts, hemodilution after fluid resuscitation and soft tissue contusion affecting hematocrit values that may resulted in over-estimation of blood loss. Study admits that transfusions were carried out at higher admission hematocrit cut -off level of less than 40 and concludesthat higher than usual number of transfusions had been done in the study period because indications for transfusion were less strict.

Based on studies on transfusion requirements in femur shaft fractures that actually studied the requirement of transfusion for clinical indications [6,7] actual rates of transfusions are not significantly different from that of the other general trauma injuries.

The available evidence from studies that actually studied hypotension together with femur shaft fracture [11, 12,13,14,15], strongly supports that isolated femoral fracture seldom causes clinical hypotension.4 out of 5 studies show no association at all between hypotension and isolatedfemur fractures, whereas 4th study by Mitchnik et al included femur fractures different fromgeneral population injuries resulting from explosions, bullet injuries and such high energytrauma with associated potentially hemorrhagic injuries. Lynch et al [14] conclude presence of hypotension or low hemoglobin in children with closed femur shaft fractures, warrant investigation for other injuries.

Limitations: There are no randomized control trials (probably because of ethical concerns of this life threatening issue) or large-scale studies available in the literature pertaining to this research question.Those studies that are available which addressthis important clinical issue are very less in number.

Conclusion

Isolated injury of femur shaft rarely results in clinical hypotension. If, actual hemorrhagic shock is suspected in cases, focusing only on femur shaft fracture as the cause of it can actually be misleading in such cases as potentially other life-threatening source of bleeding may be missed and may eventually prove to be fatal to the patient. One must actively search for other explanations of hypotension in isolated closed femur shaft fracture such as decreased physiological cardio-pulmonary reserve,sources of major internal bleeding (pelvic, chest or abdominal) or previous bleeding prior to patient arrival in emergency room, and/ ornon-obvious external sources such as bleeding from back of the patient lying on an emergency trolley.

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