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Review Article

Overview of Neurovascular Injuries in Pelvis Fracture

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Abstract

Pelvic fractures are very common injuries with associated high mortality rates. They are more prevalent with high-impact trauma due to the strong integrity of the pelvic ring. We performed an extensive literature search of the Medline, Cochrane, and EMBASE databases from 1972 until 2019. Papers discussing the neurovascular deficits caused by pelvic fractures were screened for relevant information. The pelvis as a conduit for neurovascular structures so, any fracture will be mostly associated with neurologic and/or vascular injuries. A fractured pelvic bone may lead to a life-threatening hemorrhage that needs immediate management. The source of this hemorrhage would be the injury to any of the vascular structures in the pelvis which include; major pelvic veins, iliac arterial branches or pelvic venous plexus. The venous injury is usually easier to manage with appropriate external fixation and concomitant stabilization of the fracture; however, urgent management with angiography and transcatheter embolization will be needed for effective control of ongoing arterial bleeding. The typical neurologic injuries associated with pelvic fracture would involve L5 and S1 nerve roots; nevertheless, any other pelvic nerve can be injured as well. Up to 50% of neurologic deficits will recover with no/minor muscular sequelae. Appropriate resuscitation, bleeding control, fracture fixation and neurological assessment are the key factor to a better outcome.

Keywords: *Pelvic; Fracture; Neurologic, Vascular; Injury*

Introduction

Pelvic injuries account for 10% of worldwide mortality [1]. Moreover, it is the main cause of death in the age group of 5 to 44 years old [2]. The prevalence of pelvic fractures ranges from 4 to 9.3% and associated with organ injuries in 11 to 20.3% of the patients [3,4]. In the United States, the incidence of pelvic fractures found to be 37/100,000 individuals, yearly [5]. Pelvic fractures usually result from high impact injuries; however, it can result from low impact ones, as well [5]. The high impact injuries usually result from a motor vehicle accident or falling from height [5]. Nevertheless, the low impact injuries are more common in adolescents (mostly due to athletic injuries) and the elderly (mostly due to falling during ambulation) [5-7]. The Sacrum, iliac bone and coccyx are the bones forming the "pelvic ring", which provides structural and mechanical stability to the pelvis [5]. Therefore, the pelvic fractures are more common with high-impact trauma and other fractures/injuries will be often associated [8-10]. Mortality rate, of a direct pelvic ring injury, may reach up to 25% [11] and this can increase more with hemodynamically unstable patients (30 to 45%) [12].

In general, injury of the neurovascular structures is common and considered a medical emergency [5]. Pelvic fracture-associated hemorrhage is the most common serious complication of a pelvic injury and the subsequent active hemorrhage is a leading cause of death in polytraumatized patients [3,13,14]. The vascular injury usually results from a laceration to the venous structures rather than the arterial ones [5]. In the same context, neurological injures will mostly involve the lower last lumbar and the first sacral nerve roots [5]. If there's an associated sacral fracture, other sacral nerve roots will be involved as well [5]. This study aims to provide an overview of the associated neurovascular injuries following a pelvic fracture.

Methods

We performed an extensive literature search of the Medline, Cochrane, and EMBASE databases from 1972 until October 2019 using the medical subject headings (MeSH) terms. Papers discussing the neurovascular deficits caused by pelvic fractures were screened for relevant information. There were no limits on date, language, age of participants or publication type.

Pelvis as a conduit for neurovascular structures

The axial skeleton is connected to the lower extremities with the pelvis, which acts as a conduit for the neurovascular structures [15].

Vascular structures [15,16]

The common iliac blood vessels divide into the external and internal iliac branches, at their entry into the false pelvis. The external iliac vessels continue their course through the false pelvis, passing medially to the iliopectineal eminence. Nevertheless, the internal iliac vessels pass into the pelvis to give, visceral, somatic, limb and perineal branches. The somatic branches are; iliolumbar and lateral sacral branches, while visceral branches include; umbilical, middle rectal, inferior vesicle and superior vesicle. In the same context, limb and perineal branches include; superior gluteal, inferior gluteal, internal pudendal, and obturator.

Other vessels that can be found in the pelvis include; the median sacral artery, the superior rectal artery, the terminal branch of the aorta and the extension of the inferior mesenteric artery.

Neurological structures [15-17]

The two main neurological structures in the pelvis are the lumbar and sacral plexus; each of them is divided into ventral and dorsal branches. The first lumbar (L1) nerve root gives origins to the ilioinguinal and iliohypogastric nerves, where they enter the pelvis on the psoas muscle's surface. They supply, the root of the penis, scrotum (ilioinguinal nerve), and the skin of posterolateral part of the buttock (iliohypogarstric nerve). Moreover, the dorsal branches of L2 to L4 are the femoral and lateral femoral cutaneous nerves. They supply the iliacus, the anterior compartment of the thigh (the femoral nerve) and sensation to the lateral thigh (lateral femoral cutaneous nerve). In addition, the ventral branches of L2 to L4 are represented with the obturator nerve which supplies the adductors of the thigh.

The sacral plexus branches originate in the pelvis, which later exits the pelvis through the greater sciatic notch. The dorsal branches of the sacral plexus are; the superior gluteal nerve (L4-S1), inferior gluteal nerve (L5-S2) and the common peroneal part of the sciatic nerve (L4-S2). Moreover, the ventral branches are represented by the tibial nerve (L4-S3), which supplies the thigh, the calf, and the planter foot.

Vascular injuries in pelvic fractures

A fractured pelvic bone may lead to a life-threatening hemorrhage that needs immediate management [18]. The source of this hemorrhage would be the injury to any of the vascular structures in the pelvis which include; major pelvic veins, iliac arterial branches or pelvic venous plexus [18]. The venous injury is usually easier to manage with appropriate external fixation (to reduce the pelvic volume) and concomitant stabilization of the fracture [19]. In contrast, the fixation will not be enough in case of arterial injury, which remains one of the main causes of death in similar cases [18,20]. Urgent management with angiography and transcatheter embolization will be needed for effective control of ongoing arterial bleeding [20-22].

Expected injury according to the fracture site

An injury to the iliolumbar artery can result from any fracture involving the ilium [18]. This injury can be fatal since the iliolumbar artery is the largest nutrient vessel for the ilium and passes very close to the anterior sacroiliac joint [23]. On the other hand, the superior gluteal artery can be injured by the sharp fascia of the piriformis muscle or the severely traumatized gluteal muscles [18,19]. Additionally, injury of both superior and inferior gluteal arteries can be caused by any fractures involving; the superior part of the ischial tuberosity, the greater sciatic foramen, and the ischial spine [18]. The "open book" fracture of the pelvis, specifically type II and III, can cause an injury to the internal pudendal artery [18]. Moreover, all fractures involving the inferior ramus of the pubic bone or lesser sciatic foramen can also lead to similar injury [18]. Noteworthy, fractures of the superior part of the obturator foramen, the pubic acetabulum or the superior pubic ramus can all lead to injury to the obturator artery [18].

Computerized tomography (CT)-angiography for arterial hemorrhage

Contrast-enhanced CT is considered the most accurate non-invasive technique for a proper evaluation of active arterial bleeding in patients with pelvic fractures [24-27]. The extravasation of the contrast material is an accurate indicator of arterial injury and a probable need to perform angiographic embolization [27]. This investigation has a sensitivity of 66% to 90% and a specificity of 85% to 98% with an overall accuracy of 87% to 98% in detection of arterial hemorrhage [20,25-27]. Noteworthy, clotted blood can be easily distinguished from the extravasated one by measuring CT attenuation. The mean CT attenuation of clotted blood is 51HU (ranges from 40 to 70HU), while the mean attenuation of the extravasated blood is 132 HU (ranges from 85 to 370 HU) [24].

The leaked contrast material from the urinary tract should always be distinguished from the extravasated contrast from an injured artery [27]. Therefore, Retrograde urethrography or cystography should always be avoided before CT angiography to avoid obscuring the extravasated contrast [28].

Transcatheter arterial embolization (TAE)

TAE is considered the standard treatment in patients with arterial hemorrhage caused by pelvic fractures [20-22,29]. In the case of the initial resuscitation failure in stabilizing the patient, urgent angiography and embolization should be performed [18]. The success rate of the TAE in controlling active arterial bleeding has been reported to be 85% to 100% [21,22,29]. An extensive coagulopathy and multiple organ failure can result from prolonged hemorrhage so TAE must be administered as early as possible to be effective [30].

On performing TAE for patients with pelvic fractures, several issues should be always considered. Selective injection of the internal iliac arteries should always be done, even when the aortogram shows no bleeding because the other injured arteries may be more evident or the bleeding is intermittent [18]. Selective injection of the contralateral internal iliac artery should also be done to search for any potential bleeding [29]. Noteworthy, the "cavernosal blush", that may simulate bleeding, can be found in the distal branches of the internal pudendal artery [31]. It will appear as a homogenous stain that washes out [31].

Nerve injuries in pelvic fractures

The typical neurologic injuries associated with pelvic fracture would involve L5 and S1 nerve roots [5]. Nevertheless, whenever a sacral fracture is present; S2 to S5 sacral nerve roots may be involved as well [5]. Accordingly, urine or stool incontinence and sexual dysfunction may be present too [5]. The long-term sequelae could include osteoligamentary disorders (shortening, disabling lower back pain), and neurological deficits (neuropathological pain, distal paresia with stepping, Trendelenburg gait) [32-35]. Nerve stretching is the most common mechanism for nerve injury with subsequent lesions in lesions of the perineurium then the epineurium [36,37]. In addition, a lumbosacral plexus compression, during the sacral fracture, is another reported mechanism for injury [33,38-40].

Noteworthy, most of the neurological deficits are hard to assess in acutely injured patients and will be mostly diagnosed during follow-up [32]. The first management of neurologic lesions is mainly based on the orthopedic treatment of the fracture with different stabilization techniques (traction, external fixation or internal fixation) [32,41,42].

Injury of different nerves

The reported incidence of neurologic deficits caused by pelvic fractures is widely variable; ranging from 22% to 64% [32-34,38,43-47]. The most common injured nerve in pelvic fractures is the lumbosacral trunk, which usually accompanies iliosacral disjunction or Denis I and II sacral fractures [32,33,35,39,44]. The associated neurological deficit would involve the anterior tibial muscle and the hallux extensor muscle, which can be easily identified in the emergency setting [32]. The S1 nerve root injury is usually associated with the lumbosacral trunk lesions [32,39]. It mostly caused by a nerve contusion in Denis II and III fractures [32,38]. Moreover, the superior gluteal nerve injury is closely related to the lumbosacral trunk lesions, which makes it difficult to identify in the acute phase [39,45]. This nerve could not be injuries by a sacral fracture; however, this can happen due to stretching caused by ascension of the hemipelvis [32].

The sciatic nerve palsy has been reported, which is a result of acetabular fractures [48,49]. The pudendal nerve injury should be bilateral to be clinically evident [50]. This injury can be identified by the examination of the anal sphincter function [32]. The lateral cutaneous nerve of the thigh injury has been also reported although of being easily missed during examination [41]. Less commonly injured nerves include the femoral nerve and the obturator nerve have been also reported in the literature [32,39,42].

The recovery rate of neurologic deficits

Up to 50% of neurologic deficits will recover with no/minor muscular sequelae [32,33,51,52]. In the case of lumbosacral trunk injuries, a recovery of the anterior tibial lesion can occur since the injured L4 is not the only innervation [32]. However, the hallux extensor deficit will persist with inability to extend the big toe [32]. Regarding S1 nerve root injury, most of the patients will experience some sort of improvement during follow up that may reach up to 100% [32,39].

Sciatic nerve palsy had shown excellent recovery rates with 88% of functional recovery reported [49]. The lateral cutaneous nerve of the thigh injury has also shown complete recovery in most patients [41]. The femoral nerve and the obturator nerve injuries usually have a favorable long-term improvement with recovery detected in most patients during the follow up [32,42].

Prognosis of patients with neurovascular injuries

The patient's death caused by bleeding usually happens within the first 24h so, early detection and management is a vital factor in the survival [53]. Early stabilization of the pelvic fractures along with controlling the life-threatening hemorrhage are the key factors for a better prognosis [54-57]. However, with pelvic fractures associated with iliac wing injury or sacral fractures, posterior pelvic displacement, the outcomes are poor [5].

The reported mortality rate in patients who have undergone TAE within 3 hours of their injury was 14%, whereas mortality of 75% has been recorded in patients with longer durations [21]. Moreover, patients who underwent TAE before laparotomy has a mortality rate of 25%, nevertheless; those who underwent laparotomy first showed a mortality rate of 60% [58].

There are many factors that predict the patient's risk to develop further complications and affect the final outcome. These factors include pelvic fracture type and site [58,59], quality and speed of initial resuscitation [60], patient's systolic blood pressure [61], patient's age [61], conscious level on admission [61], pelvic hematoma volume and site (as detected by CT) [62,63], the detection of extravasation (as detected by a contrast-enhanced CT) [20,24-27] and presence of nerve injuries [47].

Conclusion

Pelvic fractures are common conditions that can be life-threatening. They can be associated with serious vascular and neurological damage which require urgent intervention. Appropriate resuscitation, bleeding control, fracture fixation and neurological assessment are the key factors to better outcome. The prognosis is good with fast admission and management; however, the mortality rates can be high with neglected cases.

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Conflicts of Interest

No conflicts related to this work.

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