Trauma Case Reports 26 (2020) 100292

Contents lists available at ScienceDirect

Trauma Case Reports

journal homepage: www.elsevier.com/locate/tcr

Case Report

Potentially serious adverse effects from application of a circumferential compression device for pelvic fracture: A report of three cases

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ARTICLE INFO

Keywords:
Pelvic circumferential compression device
Pelvic fracture
Complication
Acetabular fracture
Vessel injury
Muscle necrosis
Bladder rupture
Pelvic binder

ABSTRACT

Pelvic circumferential compression devices (PCCDs) have gained wide acceptance in the management of patients with pelvic fracture. These devices are considered safe due to their non-invasive nature and significant hazards associated with the use of PCCDs have not been reported previously. However, we present herein the cases of three patients who received PCCD application and eventually developed major complications presumably caused by PCCDs. As a result, one patient developed surgical site infection following internal fixation and required several debridements. Another patient ended up with a walking disability. The remaining patient eventually died from exsanguination following application of the PCCD. Clinicians should be aware of the potential for deleterious effects, including bladder rupture, muscle necrosis, and vessel injuries. In particular, application for acetabular fractures and prolonged application of PCCDs should be avoided.

Case reports

Case 1

A 63-year-old woman was injured in an auto-pedestrian accident and was transferred to a regional hospital. The initial anteroposterior pelvic radiograph and contrast-enhanced computed tomography (CT) revealed an anteroposterior compression-type pelvic injury as well as open fracture of the left femoral shaft (Fig. 1A). She received a T-POD® (Pyng Medical Corporation, Richmond, Canada) immediately followed by insertion of a Foley catheter. Initial urine flow was clear and yellow. After fluid resuscitation, she was transferred to our emergency room (ER) for further treatment. Due to persistent hemodynamic instability, she underwent additional CT with intravenous contrast in our institution, revealing incarceration of the bladder in the diastasis of the pubic symphysis (Fig. 1B). At this point, hematuria was noted. Subsequently, the pelvic circumferential compression device (PCCD) was loosened and converted to external fixation. While extraperitoneal bladder rupture was detected on CT, no surgical repair was undertaken. After plate fixation of the pubic symphysis on post-injury day 6, surgical site infection developed in 2 weeks, requiring irrigation and debridement several times until bone union.

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https://doi.org/10.1016/j.tcr.2020.100292
Received 13 January 2020; Accepted 17 February 2020
Available online 06 March 2020

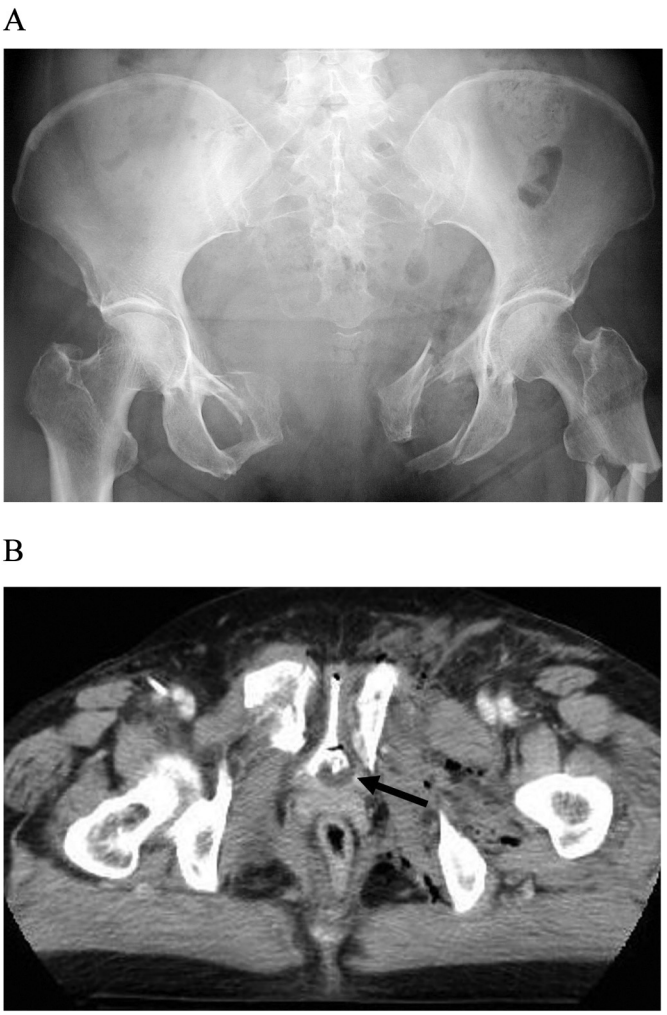

Fig. 1. A 63-year-old woman. A) Anteroposterior radiograph of the pelvis at the regional hospital. B) Axial CT cystogram demonstrating incarcerated bladder between the pubic symphysis. Arrow indicates a balloon of a Foley catheter.

Case 2

A 17-year-old boy sustained a pelvic fracture with left acetabular fracture, splenic rupture, intraperitoneal bladder rupture, and left renal laceration after a fall from height. A SAM-Sling® (SAM Medical Products, Newport, OR, USA) was immediately applied in the hybrid ER due to signs of hemodynamic instability. Subsequently, selective embolizations of the right superior gluteal artery, left lateral sacral artery, and posterior branch of the left renal artery were performed. After angioembolization, splenectomy and repair of the bladder were performed in the operation room. The PCCD was applied for 14 h until physiological status stabilized and coagulation profile normalized. Serum creatine kinase levels subsequently showed a gradual increase, peaking at 39,386 IU/L on post-injury day 5. The patient underwent contrast-enhanced CT 8 days after injury, revealing muscle necrosis bilaterally on the anterior side of the pelvis (Fig. 2A). No angioembolization had been performed for this area. Retrospectively, the position of the PCCD on the initial CT and the distribution of muscle necrosis on second CT were reconstructed on 3-dimensional images (Fig. 2B, C). These revealed that muscle necrosis completely matched the position of the PCCD. Due to the high risk of surgical site infection, open reduction of the anterior side of the pelvis was avoided, and internal fixation was delayed until post-injury day 15. The patient underwent percutaneous screw fixation, achieving bone union without infection. He ultimately returned to daily activities with moderate walking disability and muscle weakness of flexors and abductors of the hip.

Case 3

A 23-year-old woman suffered multiple injuries in a fall from height. She was brought in by ambulance to our institution with hemodynamic instability. Signs indicative of pelvic deformity were identified, and a SAM-Sling® was applied upon arrival to the ER (Fig. 3A). After application of the PCCD, systolic blood pressure decreased continuously and resulted in more profound shock. Pre-

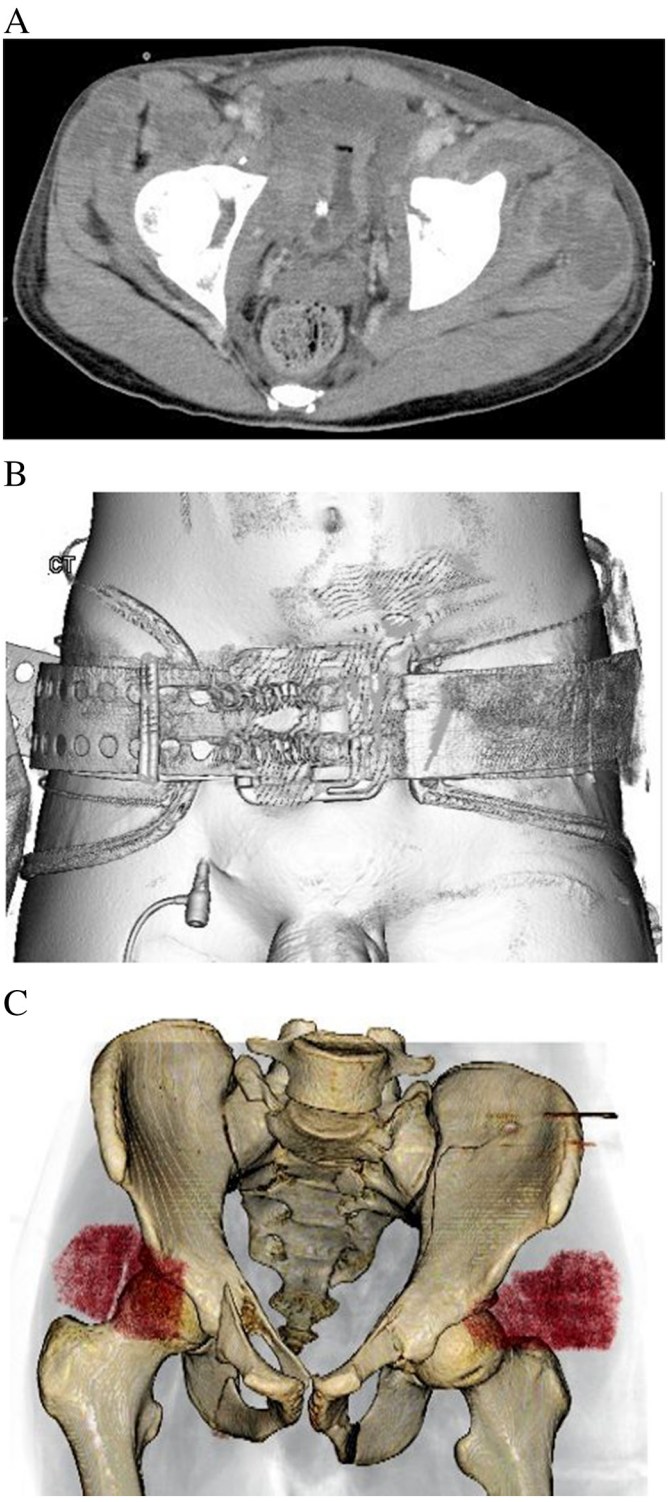

Fig. 2. A 17-year-old boy. A) Contrast-enhanced, delayed-phase CT demonstrating multiple areas of muscle necrosis over the anterior side of the pelvis. B) Reconstructed 3D-CT shows the position of the PCCD on admission. C) Reconstructed 3D-CT shows the area of muscle necrosis (brush dots). The positions of the PCCD and muscle necrosis completely overlap.

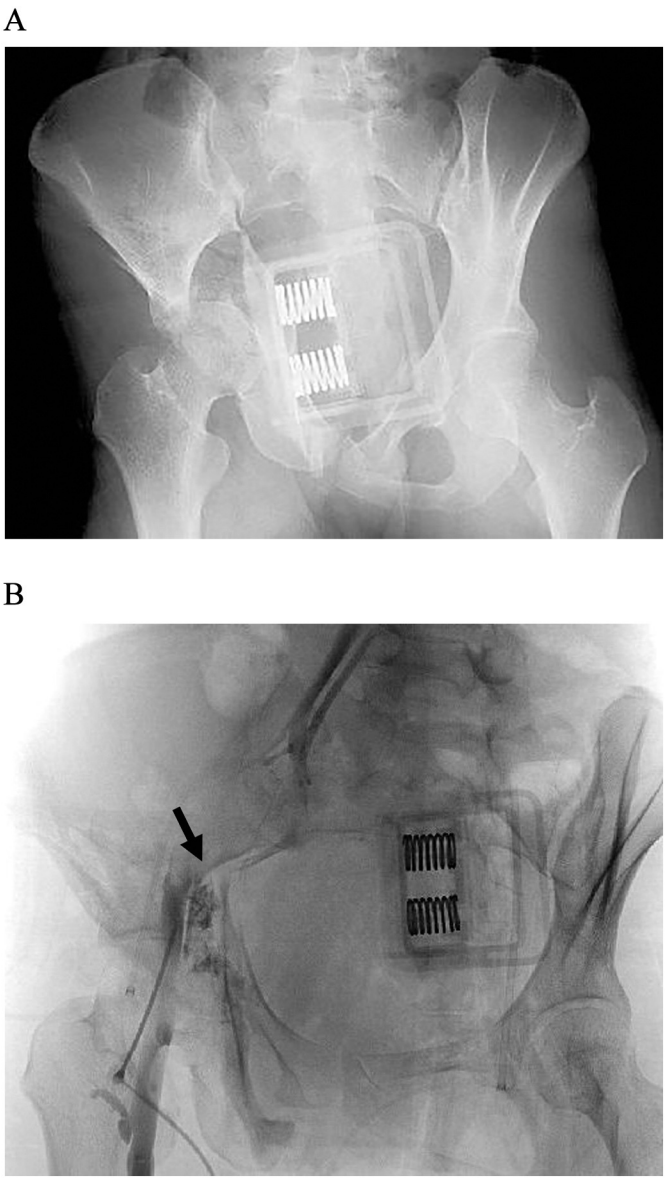

Fig. 3. A 23-year-old woman. A) Anteroposterior radiograph on admission. The right quadrilateral surface is displaced medially. B) Venography of the external iliac vein shows extravasation at the closest point to the fracture edge (arrow).

peritoneal pelvic packing was followed by resuscitative endovascular balloon occlusion of the aorta (REBOA) into zone I. Arteriography during partial REBOA showed extravasation from multiple small branches of bilateral internal iliac arteries, which was managed successfully with nonselective embolization. However, due to persistent hemodynamic instability with ongoing transfusion requirements after angioembolization, venography of the external iliac vein was eventually performed. The hemorrhage demonstrated massive extravasation from the right external iliac vein was shown (Fig. 3B). Until venography, no physicians had noticed that the main injury was displaced acetabular fracture with a comminuted sacral fracture. After removal of the PCCD, depacking of the pelvis and direct ligation of the external iliac vein was attempted. The patient subsequently died due to coagulopathy and exsanguination from pelvic and maxillofacial hemorrhage 5 h after arrival.

Discussion

Over the last two decades, PCCDs have been widely accepted in the management of patients with pelvic fracture in the emergency department setting [1–4]. No significant morbidities have been reported even for lateral compression-type injuries, including acetabular fractures [9–11]. Thus, to date, early application of a PCCD has been accepted in the absence of radiographic assessment, even in prehospital settings if there is any suspicion of pelvic fracture [3,5–8].

However, PCCDs appear to risk various complications. While the nature, severity, and rates of PCCD-related complications remain unknown, skin blisters or breakdown on prolonged application, worsened sacral nerve root injury, and pelvic visceral injury have been described [12]. However, few reports regarding the detailed features of complications and clinical courses of patients have been published [7,13,14]. The present report describes initial management and complications confirmed radiographically. In particular, misjudgment of the suitability of PCCD application for acetabular fracture could lead to serious complications of vessel injuries.

Garner et al. reported a case of hemodynamic deterioration associated with prehospital application of a PCCD [13]. They showed a plain anteroposterior radiograph that apparently depicted acetabular fracture. Active hemorrhage from a site adjacent to the acetabular fracture with medial displacement of the femoral head was observed. Toth et al. described a case of femoral artery injury in which a PCCD was applied to combined injuries of the pelvis and acetabulum [11].

In our cases, the maximum duration of PCCD application was 14 h. No upper limit to the duration of PCCD application has yet been established, since each PCCD shows a unique pattern of pressure distribution and original design [15]. In addition, patient factors including body mass index, waist size, and age could also affect the tolerable duration of application [15]. Some guidelines have suggested that PCCDs should not be kept in place for more than 24–48 h [2,4]. As the long-term effects of PCCDs remain unclear and pressure sores could easily result in patients with local soft-tissue compromise due to the injury, removal as soon as possible appears reasonable [4]. However, the necessity for emergent pelvic external fixation has not been strongly advocated since standardization of the routine use of the PCCDs. One guideline suggested that PCCDs have largely replaced external fixation for achieving early mechanical stabilization of pelvic fracture [16].

The bladder and urethra are among the most commonly injured organs in anteroposterior compression-type injuries of the pelvis. One author reported 10 bladder injuries and three rectal tears among patients with PCCD application; while all of these were unlikely to have been solely attributable to use of PCCDs, the possibility could not be excluded [11]. In one of our cases, radiographs suggested that the reduced diastasis of the pubic symphysis had entrapped the bladder. This would have been preventable if a Foley catheter had been inserted prior to application of the PCCD.

One potential objection to the theme of this report is that the complications shown may have resulted from the original pelvic injuries or other factors. Since all complications were detected after the application of the PCCD, distinguishing between those attributable to the original injuries and those associated with the PCCD was difficult. However, as the radiographs showed, it seems reasonable that the PCCDs exerted some deleterious effects on the development of these serious complications. The bladder entrapment was observed between the pubic symphysis on CT cystography. The hemorrhage from the external iliac vein compressed by the fracture edge was confirmed on venography. The unusual distribution of muscle necrosis completely matched with the position of the PCCD on the reconstructed 3D-CT. Exclusion of possible iatrogenic factors of compression around the pelvis was difficult in our cases.

Conclusions

The purpose of this report is to raise awareness of the possibility that bladder rupture, muscle necrosis, and external iliac vein injury can appear following PCCD application for pelvic fractures. The cases presented here are clearly anecdotal. Further, most of them may be avoidable if appropriate application is made. However, we would like to provoke a sense of caution and awareness that PCCDs may be associated with adverse effects that could potentially result in serious complications.

Declaration of competing interest

The authors declare that we have no conflict of interest in connection with this paper. All authors confirm that they have no financial and personal relationships with other people, or organizations, that could inappropriately influence this work.

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