

Original Article

Effectiveness of Pelvic Binders in Pre-Hospital Emergency Care: A Systematic Review of the Literature

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Abstract

Background: Pelvic fractures as derived by high energy trauma are uncommon, accounting for 3-8% of all skeletal injuries. In polytrauma patients, this percentage may reach up to 25% with a mortality rate of 7-47%. **Objective-Methodology:** The purpose of the study was to conduct a systematic review of the literature in order to search for evidence concerning the safety and effectiveness of pelvic binders in pre-hospital care. **Results:** It was observed that several authors suggest that the primary stabilization of such a type of injury by means of an external pelvic binder may be beneficial in patient's initial resuscitation. However, there is still a controversy regarding their usefulness as compared to potential side effects, such as the excessive rotation of hemi-pelvis, false radiographic findings and skin pressure ulcers. **Conclusions:** In general, emergency care providers are advised to use these systems due to ease in use and relatively low cost, despite the potential but rare, side effects.

Keywords: Pelvic ring – Trauma – Pelvic binders – Pre-hospital care

Introduction

Pelvic ring fractures are quite uncommon, accounting for 3-8% of all skeletal injuries, but in cases of multiple or high-energy trauma, there might be an increase to nearly 20% (Papakostidis and Giannoudis, 2009; Chesser, Cross and Ward, 2012). Such injuries may occur after traffic injuries, crush or blast injuries

or falling from a height. The mortality rate that is reported in patients with pelvic ring fractures ranges from 7 to 47% (Chesser, Cross and Ward, 2012). These fractures could be fatal due to internal hemorrhage thus it is vital to control bleeding as quickly as possible. Especially in unstable fractures, the role of anatomical reduction, restoration of structural integrity and immobilization of the

pelvic ring is crucial in order to control the haemorrhage (Lee and Porter, 2007; Papakostidis and Giannoudis, 2009; Chesser, Cross and Ward, 2012).

Many authors advocate the immediate mechanical immobilization of pelvis in multiple trauma patients. Consequently, the increased application of pelvic devices for immobilization in patients with pelvic fractures has become a routine for emergency care providers, thanks to their fast and effective, frequent implementation (Lee and Porter, 2007; Chesser, Cross and Ward, 2012). In accordance with the guidelines of Advanced Trauma Life Support (ATLS), external pelvic devices for immobilization should be applied whenever there is a high clinical suspicion for pelvic fracture and the patient is in shock (Lee and Porter, 2007; Chesser, Cross and Ward, 2012). However, in cases where these pelvic binders are implemented in an inappropriate manner, they might be harmful especially in unstable pelvic rings (Lee and Porter, 2007). Preferably, a pelvic binder which could be placed over the greater trochanters can offer optimum reduction and immobilization (Lee and Porter, 2007; D'Alleyrand, Dutton and Pollak, 2010; Chesser, Cross and Ward, 2012). It would be advantageous if the binder could be placed symmetrically on the pelvis. However, further studies should emphasize on the indication of normal body creases as guidance points for the suitable application of pelvic binders as there is a lack in literature regarding this issue.

The purpose of the current manuscript was to conduct a systematic review of literature in order to investigate the role of pelvic binders in pre-hospital emergency care. We aim to provide data over the efficacy and safety of these devices in management of severe hemorrhage in patients with multiple trauma.

Methods

Methodology

The systematic review of literature was performed in accordance with the methods referred in "Preferred Reporting Items for Systematic Reviews and Meta

Analyses" – PRISMA. All studies included in this systematic review were original articles related to the inquiry of the manuscript. Articles, published between 2000 and 2020, that reported pelvic ring fractures treated with temporary and non-operative immobilization, were included in our study. Thus blinded trials, case studies, case reports and cohort studies that were evaluated by peer-reviewers and published in the English language, were reviewed. On the contrary, surgical techniques, book chapters or published articles written in other languages, were excluded from our study. Moreover, expert opinions and judgments, as well as advertisements, were also excluded.

The terms "pelvic", "injury", "pelvic binder", "temporary pelvic binder" and "pre-hospital care", were searched consecutively in the most popular databases such as "Embase", "CINAHL", "Google Scholar", "Medline/PubMed", "Scopus" and "Web of Science".

The initial research resulted in 426 articles. The articles fulfilling the inclusion criteria were evaluated systematically for their index. 238 studies whose titles were not in compliance with our inquiries were excluded, along with 84 duplicates. All abstracts obtained were further reviewed. The full texts of articles that were relevant to our inquiry were acquired and revised according to the aforementioned inclusion criteria. References of full texts were also assessed in order to track other potentially relative studies. Finally, 40 studies were reviewed and utilized in our article. The whole process is demonstrated in the following flow chart (Figure 1).

Pelvic Binders: Pelvic ring fractures can be classified according to the anatomical type of injury or mechanism of fracture. Historically, many classification systems have been proposed with the most popular being the Tile-AO classification which distinguishes fractures to stable and unstable and the revised version of this classification of Young and Burgess which is based on the direction of mechanical violence of injury (Grant, 1990). Therefore, sideways injury results

in Lateral Compression (LCI, LCII, LCIII), anteroposterior damage results in Anteroposterior Compression (API, APII, APIII) and vertical forces give rise to Vertical Shear injuries (Grant, 1990). Despite a plethora of classification, in clinical practice it may pose a challenge to get a specific diagnosis on an emergency basis before hospital arrival.

In December of 2013, the Faculty of Pre-Hospital Care (FPHC) published three consensual statements. One of these attempted to give guidance to immediate care and stabilization of pelvic injuries (den Boer et al., 2011). Recommendations report that a pelvic binder should be applied if there is one of the following four factors that may compromise the integrity of the patient in any environment both hospital and pre-hospital where mechanism of injuries implies possible pelvic injury. These four factors include: pulse rate > 100 bpm, systolic arterial pressure < 90 mmHg, Glasgow Coma Scale < 13 and pain in palpation over the area of pelvis. Moreover, many efforts have been made in order to set a certain care method which would take into account the immediate reduction and stabilization of the affected pelvic ring in order to achieve improved hemodynamic stabilization. Until recently, several surgical techniques have been commonly used such as the external fixation or pelvic clamp (C-Clamp), but these were time-consuming as they required surgical environment (Figure 2). On the contrary, non-surgical approaches such as the use of pelvic binders in similar critical conditions gained gradually popularity thanks, not only to their fast, safe and ease usage, but also to their biomechanical restoration that they could offer (Figures 3 and 4). There are many types of commercially available external binding devices (pelvic foil, T-POD, SAM). Pre-hospital diagnosis of a pelvic fracture could be a challenging task as in some cases there might be no obvious external bleeding or deformity. Grant in 1990 concluded that a common diagnostic method known as pelvic spring test which includes compression and distraction to the pelvis, has a poor sensitivity (59%)

and specificity (71%) for the diagnosis of pelvic ring fractures (Grant, 1990). Additionally, doctor's manipulations may deteriorate internal bleeding and thus this test is no longer indicated. Unnecessary use of a pelvic binder should be avoided in hemodynamically stable patients. The algorithm suggested, regarding clinical diagnosis of pelvic fractures and the appliance of external stabilization devices, after review of literature, is mentioned in the next flow diagram (Figure 5 and Table 1] (Sauerland et al., 2004; den Boer et al., 2011). The ideal pelvic binding device should be able to reduce both hemorrhage and pain. It should be easily applied and cause no further damage and should not obscure radiological findings. Moreover, it should allow surgical interventions without the need of removal. Lastly, it should be inexpensive for purchase and maintenance. For the time being, there are few indications over their use in pre-hospital environment. Studies on cadaver specimens along with clinical findings report that pelvic stability can be succeeded through the use of pelvic stabilization devices (Bottlang et al., 2002; Bonner et al., 2011; Scott et al., 2013; McCreary et al., 2020). However, there is still insufficient evidence to support the superiority of one binding device over the others. It seems that the two devices with the strongest evidence base are SAM splinters and T-POD devices (Figures 6 and 7) (Bottlang et al., 2002; Bonner et al., 2011; Scott et al., 2013; McCreary et al., 2020). It should be also mentioned that occasionally these devices might be applied inappropriately which could be attributed to insufficient training and not to an innate defective design of these binding systems. Health care providers should ensure that all personnel and medical team are adequately trained to ensure proper support. They should also take into consideration that soft tissues under the binders are at risk of pressure necrosis (Krieg et al., 2005; Jowett and Bowyer, 2007; Knops et al., 2010; Knops et al., 2011) especially in patients with low

arterial pressure (as in multiple injuries) who might be transferred on a stretcher.

Results

Systematic Review of literature

Bakhshayesh et al. report, in a sample of 73 patients with pelvic fractures who had been treated with pelvic binders prior to an initial CT-scan, that the mortality in the first month was higher in patients without a proper pelvic binder application (17%) as compared to the mortality in patients with an appropriate pelvic binder application (9.3%). However this difference was statistically insignificant ($p=0.562$). They also found that there was a considerable number of patients who had been inadequately treated without a proper use of pelvic stabilization devices and therefore they propose that future studies should further investigate, with the use of 3D imaging, clinical implications of inappropriate use of pelvic binders (Bakhshayesh, Risling and Enocson, 2019).

Croce et al., in a retrospective study compared the outcomes of surgical external fixations to those of pelvic binders (POD devices). Inclusion criteria in their study were multiple pelvic ring fractures with blood vessel injury and severe retroperitoneal hematoma (APCII, III). Each examined group involved 93 patients that were treated with external fixation and pelvic binder subsequently. In the latter group, the 24-hour transfusion (4.9 vs 17.1 $p<0.0001$) and 48-hour transfusion (6 vs 18.6 $p<0.0001$) was statistically lower than the group with external fixation. Mortality was also lower in the group with pelvic binders but it was not statistically significant ($p=0.11$). It was also noted that during the 10-year period of study there was a reduction in total use of external fixation (Croce et al., 2007). Fu et al. in a cohort study compared two groups, the first included patients treated with pelvic binders during their transportation to the trauma center while the second comprised patients without any pelvic binder application. During the 53-month period, 585 patients participated in the study. It was observed that the patients

in the first group had received fewer transfusions (398.4 ± 417.6 ml vs 1954.5 ± 249 ml, $p<0.001$) and were hospitalized for a shorter period (9.4 ± 7 days vs 19.5 ± 13.7 days, $p=0.006$) than those in the latter one (Fu et al., 2013). McCreary et al., assessed the necessity of pelvic binders in accordance with vital signs and mechanism of trauma, prior to hospital arrival. Their 2-year retrospective cohort study examined patients that were subdivided according to their initial pre-hospital findings, to hemodynamically stable (heart rate < 100 bpm, systolic arterial pressure ≥ 100 mmHg and Glasgow coma scale ≥ 13) or hemodynamically unstable. Hemodynamic state was evaluated as a prognostic factor of pelvic fractures requiring intervention into a 24-hour window. There were 376 patients with a pelvic stabilization device during their arrival at hospital. 137 patients were diagnosed with a pelvic ring fracture (36.4%). Out of these, 39 (28.5%) were hemodynamically stable and 98 (71.5%) were not. Subsequently, it was concluded that hemodynamically stable patients with absence of severe trauma mechanism may be excluded from urgent pelvic intervention. However, constant evaluation and supervision for negative implications of potential transition of patient hemodynamic condition, was proposed (McCreary et al., 2020).

In another retrospective study which was performed between April 2012 and December 2016, Nassem et al. categorized 1000 patients in two groups, the first consisted of patients with a confirmed pelvic fracture (lateral compression I-III, anterior posterior compression I-III or vertical shearing) and the other one included any patient that had been applied pelvic binding regardless of the radiological confirmation or exclusion of a pelvic fracture. CT examinations were reviewed and evaluated for the existence of a pelvic binder at the time of the imaging. The authors indicated that, regarding the placement of pelvic devices, more than 50% of patients had their pelvic binders misplaced which reduced their

efficacy (Naseem et al., 2018). In addition, Schweigkofler et al. examined 64 patients with pelvic ring trauma (type B or C). Their data was complemented with a graph analysis for the evaluation of transfusion necessity. They noted that 37 patients had received a pelvic binder during their pre-hospital management and 27 had not. Moreover, there was no statistically significant difference between

the investigated groups, regarding not only the severity of trauma but also the survival rate. No beneficial results were found in blood transfusion demands for patients with unstable pelvic ring trauma. However, some beneficial effect was observed in pre-hospital treatment from the use of pelvic binders (Schweigkofler et al., 2021).

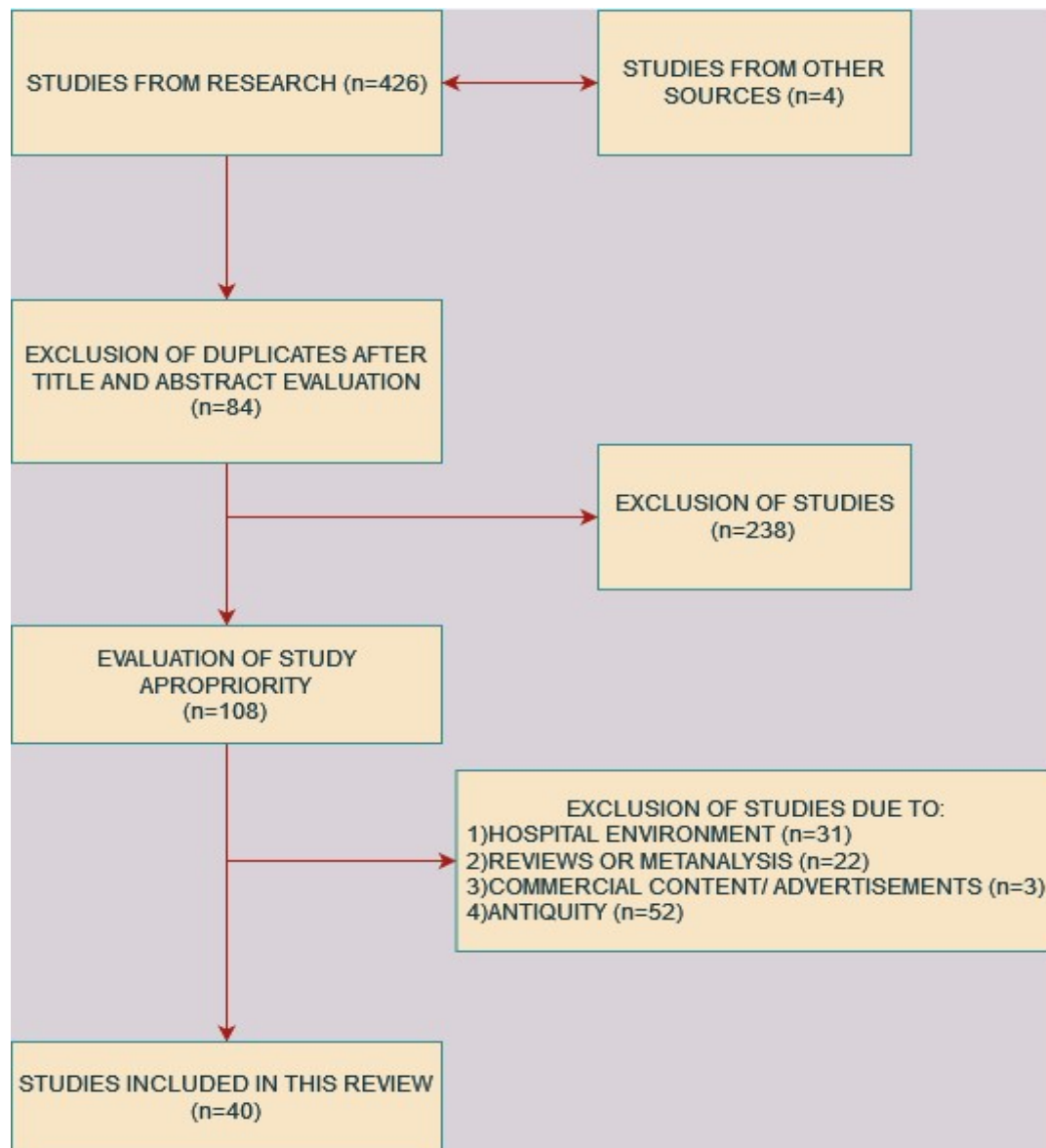


Figure 1: Flow chart regarding the articles selection for review.



Figure 2: External Fixation (Ex-Fix) for acute pelvic treatment.



Figures 3 & 4: Application of SAM Splint and Pelvic Foil subsequently.

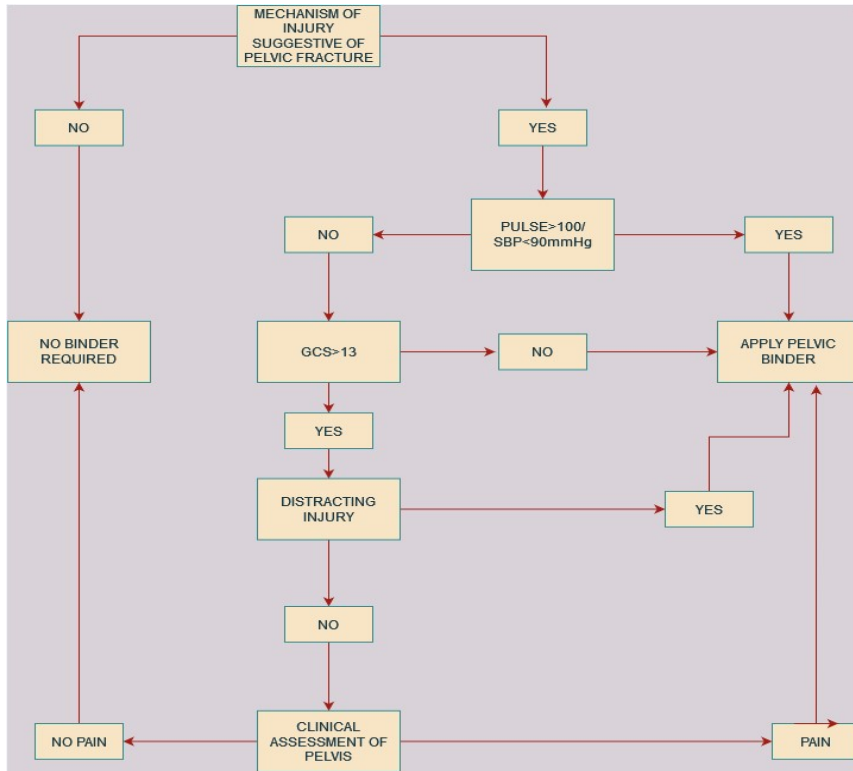


Figure 5: Flow chart regarding the application of pelvic devices.



Figure 6 & 7: SAM Splint & T-POD devices.

TABLE 1

The nature of trauma supports pelvic injury

- a. Yes
 - i. Pulse > 100, SBP < 90
 1. Yes = Apply binding device
 2. No
 - ii. Glasgow coma scale > 13
 1. No = Apply binding device
 2. Yes
 - a. Significant injury
 - i. Yes = Apply binding device
 - ii. No
 1. Clinical evaluation of pelvis
 - a. Pain = Apply binding device
 - b. Absence of pain = no binding required
- b. No
 - i. No binding required

Discussion

All the examined studies in our systematic review demonstrated combined and repetitive methodological deficiencies. There are insufficient statements clearly indicating a direct answer to our research purposes. These methodological limitations entail the lack of prospective evaluation concerning the sample size and clear efficacy of the results, whereas none of these studies was designed in accordance with the established study protocols. In parallel, due to insufficient data supporting the superiority of pelvic binding devices, no control groups were tested.

Our systematic review of literature highlights the lack of consistent high quality controlled studies that would investigate the efficacy of pelvic binders. The existing literature remains poor, consisting mainly of heterogeneous cases. Although some authors advocate over the routine use of pelvic stabilization devices, it seems that outcomes, which strongly support the pre-hospital admission of pelvic binders, rely mostly on studies that were performed in a controlled environment and there is no universal

consensus, despite some indications, regarding the application of pelvic binders.

From the review of literature it was noted that pre-hospital application of pelvic stabilization systems, imposes the necessity for further training of all medical staff and emergency healthcare providers (D'Alleyrand, Dutton and Pollak, 2010; Knops et al., 2010; Yong et al., 2016; Naseem et al., 2018; Bakhshayesh, Risling and Enocson, 2019). Even if there are concerns over the use of pelvic binders in lateral compression fractures as they might be dangerous, the Advanced Trauma Life Support dogma of "No More Harm" should be taken into consideration. On the other hand, if such devices are considered as an additional section of pre-hospital care procedures, their use should be further assessed.

Several studies encourage the positive effect of pelvic stabilizers during the initial phase of resuscitation (Ghaemmaghami et al., 2007; Nunn et al., 2007; Papakostidis and Giannoudis, 2009; Tan, van Stigt and van Vugt, 2010; Fu et al., 2013; Scott et al., 2013; McCreary et

al., 2020; Pierrie et al., 2021; Schweigkofler et al., 2021). However, the holistic outcomes of these binders are still unclear especially those concerning the mortality, duration of hospitalization, or Intensive Care Unit (ICU) length of stay. Nonetheless, pelvic binders could be a viable choice during patient transportation to trauma centers (Fu et al., 2013; Scott et al., 2013).

Almost all pelvic stabilizing devices induce pressure around the bony prominences greater than 9,3 kPa (Knops et al., 2010). Theoretically this pressure could cause skin sores 2-3 hours after constant application (Jowett and Bowyer, 2007; Knops et al., 2010; Knops et al., 2011). Based on this potential finding, early transfer to hospital and early removal of the binder could be recommended prior to definitive treatment.

Characteristic findings that could indicate severe pelvic trauma during examination include deformities, bruises, edema over the iliac spine, pubic area, perineum and scrotum, or even limb length discrepancy. Trauma over the pelvis or bleeding from rectum, urethra or vagina can be also observed. Neurologic deficits might be also attributed to pelvic fractures (Sauerland et al., 2004; den Boer et al., 2011). In a patient who is orientated, the evaluation of a pelvic fracture is obtainable. On the contrary, in cases where the injured patient is unconscious, clinical signs for pelvic ring fractures should be inspected and the healthcare provider should act accordingly.

In any case, the external pelvic stabilizers are not capable of stopping arterial bleeding. In patients who display hemodynamic instability despite the proper application of pelvic binding devices probably due to internal severe pelvic bleeding, a fast diagnostic and therapeutic approach should always be conducted.

Conclusion: Pelvic binders have shown promising results in reduction and stabilization of a fractured pelvis. Due to their low cost, easy and quick appliance

and beneficial profile, their immediate use is recommended by many authors in case of high suspicion for pelvic ring injury. They can be applied in the pre-hospital environment prior to radiological diagnosis, in a similar manner as a cervical collar is placed for cervical spine trauma, in order to decrease the possibility for further injuries before the final treatment.

However, the long-term results regarding the mortality rate, duration of hospitalization and the need for transfusion are controversial and further studies, with clinical, biomechanical and hemodynamic criteria, should be performed in order to elucidate if there is a certain long-term profit by their use and whether a wide application of pelvic binders could be strongly proposed at least for the early phase of resuscitation.

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