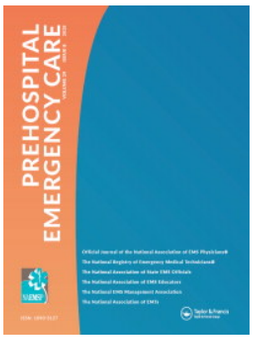

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Prehospital Trauma Compendium: Evaluation and Management of Suspected Pelvis Fractures – An NAEMSP Position Statement and Resource Document

John W. Lyng[a], Joshua G. Corsa[b], Brad D. Raetzke[c], Bryan R. Wilson[d], Andrew McCoy[e], Steve C. Patterson[f], Amie Rose[g], Emily Kraft[h] and Nichole Bosson[i]

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ABSTRACT

Emergency Medical Services (EMS) clinicians may encounter trauma patients with major pelvic fractures from multiple mechanisms of injury. In-hospital evidence that stabilization of pelvic fractures leads to improved patient outcomes has been extrapolated to promote the use of pelvic stabilization interventions by EMS clinicians in the prehospital setting. However, there are significant challenges in accurately identifying pelvic fractures in the field, and the clinical benefit of prehospital pelvic stabilizing interventions with use of pelvic circumferential compression devices (PCCDs) is questionable. Therefore, NAEMSP conducted a structured review of the literature to develop evidence-guided recommendations for the prehospital management of suspected pelvic fractures.

NAEMSP RECOMMENDS

- While hemorrhagic shock directly attributable to pelvic fractures may occur, concomitant injuries are commonly the cause of shock. EMS clinicians should carefully evaluate for other sources of shock in the hemodynamically unstable trauma patient with suspected pelvic fractures.
- EMS clinicians should recognize the challenges in accurately identifying pelvic fractures by physical exam alone. Manual stability testing of the pelvis is neither sensitive nor specific and may cause harm.
- Prehospital use of PCCDs should be reconsidered given lack of proven clinical benefit including insufficient evidence that PCCDs reduce traumatic hemorrhage or mortality, and potential for iatrogenic injuries.
- If PCCDs are used, care must be taken to ensure they are placed in anatomically appropriate position over the trochanters, and that the legs are internally rotated by securing the feet together.
- EMS clinicians should transport patients with suspected pelvis fractures who also meet other triage criteria of the National Trauma Triage Guidelines to a major trauma center, when possible. Transport via air-based EMS may be appropriate in select circumstances.
- Pelvic splinting is a low-frequency skill that is not without risk to the patient. Agencies that include use of PCCDs in their protocols should ensure their EMS clinicians receive initial and ongoing training and education that addresses the development of both cognitive and psychomotor aptitudes related to pelvic fracture identification and management. The training should be comprehensive and directed by quality improvement programs. Pelvic fracture identification, proper patient selection, and appropriate placement and tension of pelvic splints should be emphasized.
- EMS physicians play an important role in developing curricula and leading quality management programs to both ensure that EMS clinicians are properly trained in the recognition and management of pelvis fractures and that interventions for pelvis fractures are performed appropriately, safely, and effectively.

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Introduction

Pelvic fractures occur in 17–30/100,000 population, representing approximately 11.5% of the patients presenting to Level 1 trauma centers (1–3). Emergency medical services (EMS) clinicians may encounter these injuries following high-energy mechanisms of injury (1,2,4–18). Pelvic fractures are associated with high injury severity scores and significant risk for morbidity and mortality. Studies suggest that 15–30% of patients with high-energy pelvic injuries develop shock, and many pelvis fracture patients have severe comorbid intra-abdominal, intrathoracic, and intracranial injuries (1,4,5,13,17,19,20).

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Hospital-based therapies, like pelvic stabilization interventions, are intended to reduce the risk of hemorrhage from pelvic fractures. These interventions have migrated into the prehospital setting *via* use of improvised or commercial pelvic circumferential compression devices (PCCDs), also called pelvic binders. However, some have called into question EMS clinicians' ability to identify pelvic fractures and the clinical benefit of applying PCCDs in the field (21–24).

According to Kleber et al., the original hypothesis that patient benefit is gained by reducing pelvic volume of unstable pelvis fractures through use of external noninvasive pelvic stabilizers… "is based on clinical experience and two studies" (25). Upon closer examination of the two cited studies, neither provided high-quality evidence. Tan et al., conducted a case series on 15 patients with unstable pelvic fractures and signs of hypovolemic shock who were treated with PCCDs in the emergency department (ED): five patients were excluded due to incomplete data, seven patients showed a 'good response,' one showed a 'transient response,' and two showed 'no improvement' (26). Grimm and colleagues demonstrated increased retroperitoneal pressure following placement of an external fixator (not a PCCD) in an artificial pelvic injury model in nine cadavers (27). Because the benefits of PCCD in the EMS setting are uncertain, NAEMSP performed a review of the evidence regarding EMS management of pelvic fractures and developed the following recommendations and summarization of the evidence.

Methods

Content Areas

Six topic areas were identified by the author group through initial literature review, collective author experience, and discussion to achieve consensus on the priorities for evidence-based guidance in managing suspected pelvis fractures in the prehospital setting. These topic areas include:

1. Epidemiology: What is the epidemiology and clinical impact of pelvic fractures?
2. Hemorrhage and Mortality: What is the relationship between pelvic fractures, hemorrhagic shock, and mortality?
3. Field Identification: Can pelvic fractures be reliably identified in the field?
4. Splinting interventions: What pelvic binding techniques are available in the prehospital setting, and what are their indications, contraindications, benefits, and complications?
5. 5. Triage and Transport: Should suspicion of pelvic fractures impact triage and transportation decisions?
6. Special populations: Are there special populations (pediatric, geriatric, obstetric, or obese patients) that have unique needs when a pelvic fracture is suspected in the field?

Search Strategy

We performed a rapid review with a structured literature search using guidance developed for the NAEMSP Prehospital Trauma Compendium (28). The search strategy was amended to identify literature relevant to prehospital identification and management of pelvis fractures (Supplemental File Table A). The search was executed using the Pubmed database on 27 December 2022. To capture new evidence published during our initial synthesis of evidence, the search strategy was re-executed on 11 December 2024 to identify articles published between 2022 and the secondary search date.

Screening of Publications

The lead author (JWL) screened manuscript titles and excluded papers that were not relevant to the study population, clinical environment, or interventions in question. We distributed the remaining articles across our author team for screening of abstracts, further excluding articles that were not relevant to the scope of this project. The author team then divided the remaining articles (JWL 59, JGC 22, BDR 2, AM 14, SP 15, AR 4, BRW 2) and performed a full text review of each candidate article. To identify other potentially valuable articles that may have been missed by the primary search strategy, we also performed a hand-search of reference lists from papers that were selected for full text review. Wherever possible, our review focused on literature specific to the prehospital setting and specific to interventions performed by EMS clinicians, including emergency medical technicians, paramedics, EMS-based nurses or advanced practitioners, and EMS physicians. To more thoroughly develop informed recommendations, literature including interventions performed by hospital-based clinicians was also included when pertinent.

We retained articles that addressed one or more of the topic areas. Publications that were unclear were brought to the lead author for adjudication, with an intention to retain literature that applied directly or indirectly. The authors classified included articles according to the topic areas, with articles addressing multiple topic areas included in all relevant content review.

Evidence Evaluation

All authors used a pre-established evidence abstraction form to summarize the full text articles that were included in the final project literature library. The abstracted data was then integrated and synthesized to inform the position statement recommendations. As part of a rapid review framework, and due to resource limitations, we did not use Grading of Recommendations, Assessment, Development, and Evaluations (GRADE) methodology or perform risk of bias assessments.

Development of Recommendations

The author group developed recommendations based on our summary of the evidence gleaned from our literature review. The recommendations were reviewed by the NAESMP Standards and Practice Committee and approved by the NAEMSP Board of Directors.

Results

Literature Review

Figure 1 illustrates the literature search and review strategy. The initial search yielded 408 articles, and the secondary search yielded an additional 215. After screening, 151 articles were included for full text review: 67 retrospective clinical reviews, 20 case reports/series, 15 systematic reviews or meta-analysis, 14 prospective observational/clinical trials, 11 published guidelines or consensus documents, eight rapid/non-systematic reviews, eight cadaveric studies, five technical descriptions, two editorial clarifications or opinion letters, and one survey.

Evidence Synthesis

The evidence for each of the defined content areas is summarized in the following tables:

Table 1 – Epidemiology, mechanism of injury, and classification of pelvis fractures (1,2,5–11,13–17,20,29–44); Table 2 – The relationship of pelvis fractures and pelvic binders on hemorrhage and blood transfusions (4,5,13,17,20,21,25,29,37,39,42,45–62); Table 3 – The relationship of pelvis fractures, pelvic binders, and mortality (1,5,13,15–17,19–21,23,25,29,37,39–42,45,48,49,56,59,62–72); Table 4 – Field identification of pelvis fractures (18,21,24,30,36,42,51,53,54,56,64,73–98); Table 5 – Prehospital splinting interventions for suspected unstable pelvis fractures (12,19,23,26,44,55,57,58,71,72,78,82,88,95,99–146); Table 6 – Triage and transport decisions for patients with suspected unstable pelvis fractures (3,24,43,47,49,51,65,84,114,147–149); Table 7 – Special patient populations with suspected pelvis fractures (12,31,32,34,35,40,50,65,66,86,147,150–152). Several articles provided evidence that informed multiple areas of focus within this manuscript.

Discussion

While hemorrhagic shock directly attributable to pelvic fractures may occur, concomitant injuries are commonly the cause of shock. EMS clinicians should carefully evaluate for other sources of shock in the hemodynamically unstable trauma patient with suspected pelvic fractures.

Twenty-nine studies, summarized in Table 2, discuss the relationship between pelvic fractures, hemorrhage, and the need for blood transfusion or angioembolization to control bleeding.

Pelvic fractures can result in significant hemorrhage when associated with vascular injury. A retrospective cohort study of 127 patients demonstrated that pelvic fractures with intra-pelvic arterial injury represented 11.8% of pelvic fractures, and those injuries were associated with more prehospital hemodynamic instability and higher transfusion needs (5). A retrospective review of autopsies performed on 91 trauma fatalities in a German trauma registry showed that 19% of the cohort had primary pelvic hemorrhage, 25% had

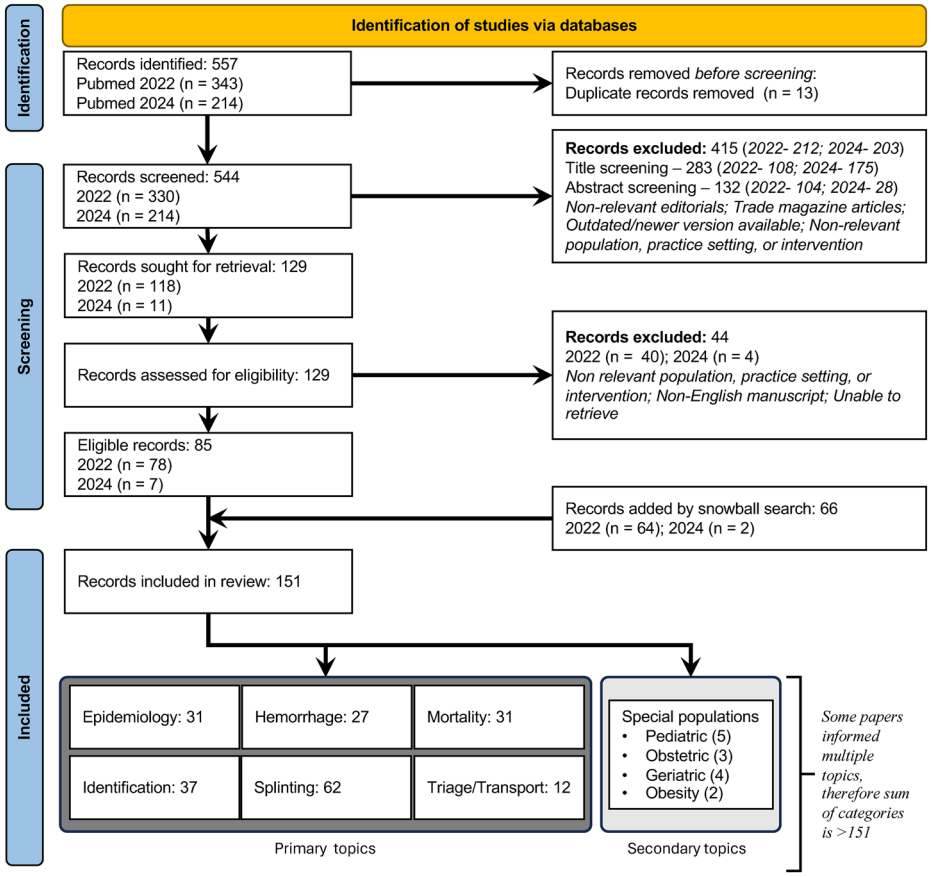


Figure 1. Literature search flow diagram.

Table 1. Epidemiology, mechanism of injury, and classification of pelvis fractures.

Author, year	Setting	Article type	# Subjects	Study description and key findings
Abboud, 2021	Emergency Department	Retrospective Review	127	11.8% of patients with high energy blunt mechanism pelvic ring injury had intra-pelvic arterial injury (8.6% in lateral compression injuries, 33.3% of anterior-posterior compression injuries, and 23.5% of vertical sheer injuries). Patients with intra-pelvic arterial injury were more likely to have prehospital hemodynamic instability and to need blood transfusion within 24 h but did not have worse mortality.
Agri, 2017	Single center Emergency Department (Switzerland)	Retrospective Review	240	No association between the use of pelvic binders or arterial angio-embolization and survival was observed in this cohort of patients with pelvic fractures. Type C fractures more often associated with falls, Type A or B fractures more often associated with road traffic accidents.
Balet, 2023	EMS	Retrospective Review	2790	A Binder used in 387 (13.9%) patients. In the binder group, 176 (45.5%) had an unstable pelvic fracture, 52 (13.4%) a stable pelvic fracture and 159 (41.1%) an injury unrelated to the pelvic region. In the group who did not receive a binder, 214 (8.9%) had an unstable pelvic fracture, 182 (7.6%) had a stable pelvic fracture, and 2007 (83.5%) had an injury unrelated to the pelvic region. The nationwide sensitivity of PCCD application was 45.1% (95% CI 40.1–50.2), the specificity 91.2% (95% CI 90–92.3), with both over- and under-triage rates of 55%. The prevalence of unstable fractures was 14% (390/2790).
Banerjee, 2009	London HEMS and Trauma hospital, Intensive Care Unit (London)	Retrospective Review	44	Retrospective case series of 44 pediatric patients with pelvic fractures who were transported by London HEMS to London Level 1 Trauma Center over 10-year period. Most common mechanism - pedestrian vs car; most fractures were stable, even in skeletally immature pelvis; associated injuries to head and other long bone. Seven deceased patients. Isolated pelvic fracture was well tolerated but many pediatric patients had complex injuries and some of those other injuries had high mortality.
Boulanger, 1992	Emergency Department	Retrospective Review	6368	Obese patients were more likely than non-obese to sustain pelvic fractures from blunt trauma (13.7 v 9%, $p < 0.01$). Similar results when motor vehicle collisions analyzed (14.6 v 10.8%, $p < 0.05$)
Buduhan, 2000	Level 1 trauma center Emergency Department (Toronto)	Retrospective Review	567	Pelvis fractures represented 7.9% of missed injuries in patients admitted to intensive care unit
Cannada, 2010	Emergency Department	Retrospective Review	10	1055 pregnant patients, of which 65 had orthopedic trauma and 10 had pelvic fractures. In patients with pelvic fractures, there was placental abruption in 30%, with 30% fetal mortality. Pelvic fractures had the highest complication rate of any of the other orthopedic injury subgroups analyzed.
Cuevas Ostrem, 2021	Registry (Norway)	Retrospective Review	11,403	Description of geriatric Norwegian trauma patients. Geriatric trauma epidemiology. In presence of pelvic/lower extremity injury AIS ≥3 increases with age beginning at age 55–64 years old.
Ellerton, 2009	Expert Consensus	Guidelines and Consensus Documents	N/A	International Commission for Mountain Emergency Medicine Consensus Recommendations. Few mountain rescue patients suffer pelvic fracture, <1%. Splinting is recommended if pelvic fracture is suspected. "Springing the pelvis" is not recommended. Splint should stay on until in the hospital.
Fox, 1990	Emergency Department	Retrospective Review	175	Of 175 patients with pelvic fractures, 51.7% were caused by motor vehicle collisions, 30.6% pedestrian struck by car with an average ISS of 24. Mortality was 16% (in 1983–1986). 43.5% had open fractures. Risk factors for mortality included age, admission blood pressure, other injuries, and open pelvic fracture.
Fox, 1991	GEMS	Prospective	500	Prehospital provider examination for specific mechanism of injury can lead to more rapid and consistent diagnosis of injury. Dashboard intrusion correlated with pelvic ($p < 0.001$) and femur ($p < 0.03$) fractures, closed head injuries ($p < 0.001$), and intraabdominal injuries ($p < 0.02$). Steering wheel deformity correlated with pelvic fractures ($p < 0.001$) and closed head injuries ($p < 0.005$). Irreparable vehicles correlated with pelvic ($p < 0.0001$) and femur fractures ($p < 0.01$), closed head injuries ($p < 0.0001$) and intra-abdominal injuries ($p < 0.0001$).
Gosteli, 2016	HEMS	Retrospective Review	616	Of the 616 patients injured from extreme sports with high-risk practice, pelvic fractures were the 10th most common injury, with 11/216 (5.02%).
Gottfried, 2024	EMS, Emergency Department	Retrospective Review	244	Registry patients from 1997–2021. Shock was recorded in 50 (20.5%) patients upon emergency department arrival, but only four of these had isolated pelvic fractures. In-hospital mortality occurred among 18 (7.4%) patients, all with non-isolated fractures.
Heim, 2014	Emergency Department, HEMS, GEMS (Switzerland)	Systematic review	1.599	Review of trauma patients across 12 Swiss trauma centers over a 5-year period. Blunt trauma representative of predominant injury pattern. Increased rates of pelvic/extremity injuries as compared to German 10-year study (40% vs 31.3%), felt likely due to increased two-wheel trauma. Compared to California trauma facilities, motorbike trauma workload was substantially higher (28.5% vs 4.3%). Mortality rates were 50% higher in study hospitals compared to English, Dutch, and German populations (25% vs 13%, 22%, and 19.3%, respectively). Core conclusion of the article advocates for development of regional trauma systems to reduce overall system mortality, as seen in other systems that have a well-organized regionalized trauma system.

(*Continued*)

Table 1. Continued.

Author, year	Setting	Article type	# Subjects	Study description and key findings
Hill, 1993	Emergency Department	Systematic review	705	Pedestrian trauma patients over 3-year period. During 1 year of the study period (1990–1991) 70% had pelvic and lower injuries, head injuries in 66%, chest injuries in 42%. Mortality rate was 30%. 10% (5/50) died within first day from exsanguination, 9/50 died subsequently from head injury.
Balogh et al., 2007	Emergency Department, EMS	Prospective	138	Descriptive study of pelvic ring fractures in patients presenting to level 1 trauma center in South Africa. 23 pelvic ring fractures per 100,000 people. Divided into low energy and high energy mechanisms; different demographics but similar mortality. Incidence of high energy pelvic ring fractures 10 per 100,000 persons per year, low energy 10 per 100,000 persons per year, and prehospital deaths due to pelvic ring fracturs 3 per 1,000,000 person per year. Type A 61%, B 25%, C 13% (all comers). Peak incidence of high energy and prehospital death between 10 and 40 years old, low energy over 80 years old
Markogiannakis, 2006	Trauma center (Greece)	Retrospective Review	730	Greek trauma registry study of patients with vehicular injury looking at pattern of injury vs mechanism. Pelvic injuries were most common in pedestrian struck by motor vehicle when compared with vehicle occupants and motorcyclists. 444 motorcycle, 209 car occupants, 77 pedestrians. Pelvic injuries: 6.1% motorcycle, 12.9% car, 18.2% pedestrian ($p = 0.0001$)
Mcmurty, 1980	Emergency Department	Case series	79	19% overall mortality in 1980, 60% if concomitant neuro injury. 96.2% had both anterior and posterior fractures. 80% had posterior ring disruption. 48.1% presented in shock, 84.81% required transfusion with an average of 11 units per patient, 24 for non-survivors and 7 for survivors, and 15.5 units for posterior disruption vs 5.9 for anterior disruption. Major cause of death was hemorrhage & head injury. 82.27% had complications, average of 1.78 complication per patient. Average ISS 34.
Nutbeam, 2021	EMS	Retrospective Review	63,625	Review of 6,983 (trapped) and 56,642 (un-trapped) patients. Patients who were trapped had higher rates of pelvic fractures with significant blood loss, tension pneumothorax, and injuries to other body areas
Poole, 1991	Emergency Department	Case Series	236	Average age 31.5 years, average ISS was 21.3, average blood requirement was 5 units, and average length of stay was 16.8 days. 152 patients (64.4%) were motor vehicle collisions, 33 (14%) were auto versus pedestrian, 16 (6.8%) had crush injuries, 12 (5.1%) each had either motorcycle accidents or falls, and 11 (4.6%) had miscellaneous accidents. 18 patients (7.6%) died, with 7 (38.9%) deaths due to hemorrhage. Only one death was caused by pelvic hemorrhage. ISS was correlated with indices of severity of pelvic fractures such as fracture site ($p < 0.0001$), fracture displacement ($p < 0.005$), pelvic stability ($p < 0.0001$), and vector of injury ($p < 0.01$). Nine patients underwent pelvic angiography, three required pelvic embolization, seven had intra-abdominal hemorrhage that required laparotomy, and eight developed a coagulopathy.
Poole, 1994	Emergency Department, Intensive Care Unit	Retrospective Review	348	63% male, average age 31 years old, 65% motor vehicle collisions, 9.2% isolated pelvic injury - all others associated with other injuries, 28 died (8% mortality), 40% died of hemorrhage, only 4 died of pelvic hemorrhage (14% of deaths), authors conclude that pelvic injuries can be complex but are often simple and not life threatening
Rogich, 2020	EMS	Case Report	1	Case report of a surfing-related pelvis fracture
Soreide, 2009	Emergency Department (Norway)	Case Series	36	Scandinavian study examining autopsies on pediatric and adolescent trauma-related deaths over 10 years in Norway. 36 autopsies performed, 70% boys, predominantly in the 13–17 year-old age range. Blunt trauma in 92%, chiefly road traffic accidents, 42% being "soft" victims (pedestrian/cyclist). Spring and summertime prevalence. Vast majority succumbed to head injuries, none were due to multi-organ failure. Pelvic fixation in 1/15 patients closely studied. 7/14 patients in cohort with abdominopelvic injuries had AIS = 5, 4/14 had AIS = 4, 2/14 had AIS-6
Teh, 2003	Emergency Department	Retrospective Review	399	342 were fallers and 57 were jumpers. Jumpers had a higher ISS, death rate and number of fractures per person. Jumpers sustained more rib, pelvic, and lower limb fractures, but fewer skull fractures. Pubic fractures were the most common fracture (tied with rib fractures) noted in jumpers and the sixth most common fracture in fallers. Pelvic fractures occurred significantly more commonly in jumpers than fallers ($p < 0.01$). 34% of jumpers sustained pubic rami fractures and 14% sustained iliac fractures. In fallers, the figures were 9% and 8%, respectively. These findings may be explained by the tendency for feet-first landings in jumpers, with forces being transmitted through the femur into the hip joint and thus into the pelvis.
Tonge et al., 1972	Death registry (Australia)	Retrospective Review	908	Review of 908 traffic fatalities in Australia. Pelvic fractures occurred 21.7% of deaths; 33.2% pedestrians, 15.2% car driver, 13% car passenger, 8% cyclists, 5% motorcycle. Other details include breakdown of seat belts, alcohol use, helmets, age/sex.
Trentzsh, 2024	EMS	Retrospective Review	5880	Overall unstable pelvic ring fracture incidence was 9% ($n = 5880$) and binder use increased over time (7.5% to 20.4%). Of all cases with unstable pelvic ring fracture, 40.2% received a binder. Of all cases with binder application, 61% had no pelvic injury at all. Hospital mortality with binder was 1% lower than predicted but failed statistical significance (0.95 vs 1.04, $p = 0.101$). 1,860 propensity score matched pairs were analyzed: there was no difference in mortality or transfusion requirements.
Viel, 2019	Interfacility transfers (Brazil)	Retrospective Review	246	Pelvic girdle/extremities are the most severely injured body region for interfacility transfers (75% of cases had pelvic girdle/extremity injury).
Weber, 2017	EMS	Prospective	679	Describes epidemiology of equestrian-related traumatic injuries. 32% of patients injured in horse crush equestrian incidents had a pelvis fracture. 13% of fall from horse incidents had a pelvic fracture.

(*Continued*)

Table 1. Continued.

Author, year	Setting	Article type	# Subjects	Study description and key findings
White, 2008	Emergency Department, Operating Room, Intensive Care Unit	Systematic review	N/A	Bleeding pelvic fractures that result in instability have mortality of 40%. Because of force need for pelvic fracture, lots of associate injuries, mortality usually due to extra-pelvic sources. Unstable fractures with hemodynamic instability represent <10% of all pelvic fractures at Level 1 trauma centers.
Wong, 2017	HEMS, GEMS, Emergency Department, Operating Room, Intensive Care Unit	Non-systematic literature review	N/A	Pelvic fractures are associated with other injuries. Between 60% and 80% of patients will also have another musculoskeletal injury, 12% will have urogenital injuries and 8% with lumbosacral plexus injuries. Pelvic binders may be used. Legs should be internally rotated. Computed tomography scan modeling has demonstrated that pelvic fractures do not significantly increase the pelvic volume. Binding reduces bleeding by stabilizing the fracture rather than tamponade.
Yang, 2014	Emergency Department (Taiwan)	Retrospective Review	49,300	Over a 10-year period, the incidence of pelvic fractures in hospitalized patients in Taiwan ranged from 17.17 to 19.42 per 100,000, and an increasing trend with age was observed. The mean case-fatality rate was 1.6% for females and 2.1% for males; male patients with pelvic fractures had a significantly higher risk of death than female patients. 74.2% of these cases were combined with other injuries. The most common associated injuries were other fractures of the lower limbs (21.50%), spine/trunk (20.97%), or upper limbs (18.18%), followed by significant head injuries (17.59%), intra-abdominal injuries (11.00%), and thoracic injuries (7.20%).

AIS: Adjusted Injury Severity Score; CI: Confidence Interval; EMS: Emergency Medical Services; GEMS: Ground-based Emergency Medical Services; HEMS: Helicopter-based Emergency Medical Services; ISS: Injury Severity Score; PCCD: Pelvic circumferential compression device.

thoracic bleeding, 21% had liver, aortic, and cardiac injuries that were collectively responsible for bleeding, and 34% of patients had such extensive multisystem injuries that primary source of hemorrhage could not be determined (25). These findings are corroborated by several other studies (13,17,37,48,67).

Due to the forces necessary to cause significant pelvic fractures, they are rarely found without comorbid severe injuries, and suspicion for unstable pelvic fractures should always be considered as an indicator of severe internal injury and bleeding until proven otherwise (25). A 1980 study suggests that 48% of patients with pelvic fractures have associated hemorrhage requiring transfusion, though because this study pre-dates modern hospital diagnostic capabilities the source of the hemorrhage in these patients is unknown (39). Later retrospective investigations by Poole et al., examined 348 pelvic fractures and found high rates of blood transfusions and mortality, but most sources of hemorrhage and death were determined to be extra-pelvic (13,17). A systematic review by White in 2008 estimates that unstable pelvic fractures with hemodynamic instability represent less than 10% of all pelvic fractures (20). A review from Hak et al., in 2009 suggests that 15–30% of patients with high-energy pelvic injuries are hemodynamically unstable possibly due to blood loss from the pelvic injury, however the authors acknowledge that abdominal, head, and thoracic injuries were usually co-morbid with pelvic fractures, and they were not able to determine the actual source of shock in the literature they reviewed (4). Two large registry studies have associated pelvic fractures with comorbid signs of shock with the need for transfusions, surgery, and interventional radiology procedures (49, 53). These reports appear consistent with the fact that pelvic fractures tend to result from high-energy mechanisms and have comorbid injuries but neither review investigated actual sources of bleeding.

Thirty-three studies summarized in Table 3 discuss the relationship between pelvis fractures and mortality. Pelvic fractures have between a 2–40% risk of mortality, with most studies reporting mortality around 19% and one study suggesting a higher risk for earlier mortality (1,2,7,17,20,37, 39,40,63–67). Factors associated with increased risk for mortality include concomitant head, thoracic, and abdominal injuries; "open book" (anterior-posterior) fractures; Glasgow Coma Score (GCS) <9; prehospital shock; patients who also underwent prehospital endotracheal intubation; open pelvic fractures; pregnant and elderly patients; and injuries occurring in areas that lack a well-established trauma system (16,49,66,67,69). Three studies suggest that when pelvic fractures are confirmed to result in pelvic hemorrhage (approximately 10% of all pelvic fractures), mortality rates can approach 19–40% (20,25,92). However, those studies are contradicted by findings of Abboud et al., that suggest pelvic fractures with intra-pelvic arterial injury (11.8% of fractures in their study) did not have higher mortality rates (5).

In summary, there is evidence that unstable pelvic fractures have a causative relationship with hemorrhagic shock in some patients and, when associated with hemorrhage, mortality may be increased. Further, there is ample evidence that pelvic fractures are commonly associated with comorbid solid-organ injuries that are the more likely cause of hemorrhage in a majority of patients. Therefore, EMS clinicians should recognize that, although hemorrhage can occur due to pelvic fractures, they should view potential unstable pelvic fractures as a bellwether of other more serious sources of hemorrhage, especially in the thorax and abdomen.

EMS clinicians should recognize the challenges in accurately identifying pelvic fractures by physical exam alone. Manual stability testing of the pelvis is neither sensitive nor specific and may cause harm.

Thirty-seven articles discussed the techniques used to identify suspected pelvic fractures in the field and their accuracy (Table 4). Observational data demonstrate that it is difficult for EMS clinicians to identify pelvic fractures, with diagnostic accuracy ranging from 7.2–69% (24,64,78,83). Multiple studies have noted similar challenges with accurately identifying pelvic fractures among physicians-performed examinations in the prehospital setting (74,80,81).

Table 2. The relationship of pelvis fractures and pelvic binders on hemorrhage and blood transfusions.

Author, year	Setting	Article type	# Subjects	Study description and key findings
Impact of pelvis fractures on hemorrhage and blood transfusions				
Abboud, 2021	Emergency Department	Retrospective Review	127	11.8% of patients with high energy blunt mechanism pelvic ring injury had intra-pelvic arterial injury (8.6% in lateral compression injuries, 33.3% of anterior-posterior compression injuries, and 23.5% of vertical sheer injuries). Patients with intra-pelvic arterial injury were more likely to have prehospital hemodynamic instability and to need blood transfusion within 24 h but did not have worse mortality.
Burkhardt, 2012	Emergency Department (Germany)	Retrospective Review	402	Primary focus is on fracture type and associated injury severity. Mean ISS was 25.9, and the mean of patients with ISS ≥16 was 85.6%. The fracture distribution was: 19.7% type A, 29.4% type B, 36.6% type C, and 14.3% isolated acetabular and/or sacrum fractures. Compared to type A fractures Type B/C had consistently worse vital signs that necessitated a higher volume of fluid and blood administration in the prehospital and/or the trauma-room setting. Type B/C fractures were also related to a significantly higher presence of concomitant injuries and higher ISS, longer ventilation and intensive care unit stays, increased rate of multiple organ dysfunction syndrome, sepsis, and increased rate of mortality, at least for the type C fractures. Approximately 80% of the dead had sustained Type B/C fractures.
Burkhardt, 2014	GEMS, HEMS, Emergency Department, Operating Room, Intensive Care Unit	Non-systematic literature review	N/A	Fluid resuscitation should be limited to obtaining a radial pulse. Aggressive fluid resuscitation is associated with increased mortality, need for transfusion, and decreased clotting ability.
Carchietti, 2013	HEMS, GEMS	Case Series	3	Study evaluated the amount of vibration occurring on study subjects in flight. They found very low rates of vibration (both frequency and amplitude) in flight. Authors suggest HEMS transport imparts less vibration than GEMS transport. This may have beneficial impact on reducing bleeding from unstable pelvic fractures
Fitzgerald, 2017	Trauma center (Victoria, Australia)	Retrospective Review	1213	Many interventions initiated during study period. Widespread use of pelvic binders appears associated with mortality reduction. Similarly, the proportion of patients arriving at the trauma center with hemorrhagic shock appears lower. However, study was unable to demonstrate a statistically significant or a causal relationship, as binder introduction was part of a multi-faceted, overall effort to reduce pelvic injury mortality.
Gottfried, 2024	EMS/Emergency Department	Retrospective Review	244	244 registry patients from 1997–2021. Shock was recorded in 50 (20.5%) patients upon emergency department arrival, but only four of these had isolated pelvic fractures. In-hospital mortality occurred among 18 (7.4%) patients, all with non-isolated fractures.
Hak, 2009	Review article	Non-systematic literature review	N/A	15% to 30% of patients with high-energy pelvic injuries are hemodynamically unstable, which may be directly related to blood loss from the pelvic injury. The same forces that lead to disruption of the pelvic ring are frequently associated with abdominal, head, and thoracic injury.
Hamada, 2018	Emergency Department (France)	Retrospective Review	3675	Describes prehospital notification of trauma alerts in France. It demonstrated that traumas with any of the following (Shock Index ≥1, mean arterial blood pressure ≤70 mmHg, point of care hemoglobin ≤13 g/dl, unstable pelvis and prehospital intubation) correlated with packed red blood cell transfusion in the trauma room, or transfusion ≥4 units in the first 6 h, or lactate ≥5 mmol/L, or immediate hemostatic surgery, or interventional radiology and/or death of hemorrhagic shock.
Kleber, 2021	EMS, Emergency Department (Germany)	Combined Retrospective and Prospective Observational Study	91 in retrospective arm 36 in prospective arm	Retrospective arm designed to collect epidemiologic data from deceased patients. Autopsy used to determine cause of death, including causes attributable to unstable pelvic fractures. Unstable pelvic injury was shown to be the leading source of bleeding in only 19% of cases. Leading causes of bleeding were thoracic, peri-pelvic, hepatic, aortic rupture, and cardiac destruction. Prospective arm evaluated application of an external pelvic stabilization device (T-POD, SAM sling, pneumatic sling, or bed sheet) to cadavers with documented unstable. traumatic pelvic injuries. Application forces for each device were calibrated using a biomechanist using a tension spring. Computed tomography scan measurements showed that all PCCD techniques initially reduced pelvic volume, but improvised sheets quickly failed to maintain tension. Recommends that unstable pelvic injuries must be seen predominately as an indicator of serious, especially thoracic and abdominal, concomitant injuries. Only 1/5 of cases identified unstable pelvic fracture as the primary source of bleeding. Recommends use of a commercial PCCD over improvised sheets.

(*Continued*)

Table 2. Continued.

Author, year	Setting	Article type	# Subjects	Study description and key findings
Leighton, 2020	GEMS, HEMS, Emergency Department, Operating Room, Intensive Care Unit	Non-systematic literature review	N/A	Unstable pelvic fracture is a predictor of massive transfusion in patients over the age of 65 (OR 21.56). Tranexamic acid and prehospital blood transfusion are both safe and effective. Despite equivocal evidence, pelvic binders are the standard of care.
McCreary, 2020	GEMS	Retrospective Review	376	There were 376 patients with EMS binders on at hospital arrival. Pelvic fractures were diagnosed in 137 patients (36.4%). Of these, 39 (28.5%) were hemodynamically normal and 98 (71.5%) were hemodynamically abnormal. Of those with fractures, 40 patients (29.2%) required pelvic intervention within 24 h of admission; of these 32 (80%) were hemodynamically abnormal. As a test for pelvic fracture requiring intervention within 24 h, abnormal prehospital hemodynamics had a sensitivity of 80% (95% CI 0.64–0.91), specificity of 32% (95% CI 0.27–0.38) and NPV of 93% (95% CI 0.88–0.96). Combined with absence of a major mechanism of injury, normal hemodynamics had a sensitivity 100%, specificity 51% (95% CI 0.36–0.66) and NPV of 100% for pelvic intervention within 24 h.
Mcmurty, 1980	Emergency Department	Case Series	79	19% overall mortality in 1980, 60% if concomitant neuro injury. 96.2% had both anterior and posterior fractures. 80% had posterior ring disruption. 48.1% presented in shock, 84.81% required transfusion with an average of 11 units per patient, 24 for non-survivors and 7 for survivors, and 15.5 units for posterior disruption vs 5.9 for anterior disruption. Major cause of death was hemorrhage & head injury. 82.27% had complications, average of 1.78 complication per patient. Average ISS 34.
Mitra, 2011	EMS	Retrospective Review	1680	Review of prehospital variables associated with acute traumatic coagulopathy. Abdominal/pelvic injuries have an OR of 2.0 (95% CI 1.27–3.12) for acute traumatic coagulopathy, compared to OR 4.99 with chest decompression or OR 1.85 with entrapment
Pehle, 2003	Emergency Department (Germany)	Prospective	979	During a 45-month period involving 1160 patients, 979 were included in analysis. 928 had negative examination for clinical stability of the pelvis, 51 had positive examination findings. Those with positive pelvic findings had higher injury severity score, more shock, lower initial systolic blood pressure, lower initial hemoglobin, and higher rate of severe chest and abdominal injuries. 43 fractures were missed on exam in the 928 "negative findings" group. Physical exam had a 44% sensitivity and 98% specificity for detecting pelvis fracture. Clinical exam cannot reliably rule out surgically significant pelvic fractures (20%) in the severely injured and intubated blunt trauma patient.
Poole, 1991	Emergency Department	Case Series	236	Average age − 31.5 years, average ISS was 21.3, average blood requirement was 5 units, and average length of stay was 16.8 days. One hundred fifty-two patients (64.4%) were motor vehicle collisions, 33 (14%) were auto versus pedestrian, 16 (6.8%) had crush injuries, 12 (5.1%) each had either motorcycle accidents or falls, and 11 (4.6%) had miscellaneous accidents. 18 patients (7.6%) died, with 7 (38.9%) deaths due to hemorrhage. Only 1 death was caused by pelvic hemorrhage. ISS was correlated with indices of severity of pelvic fractures such as fracture site ($p < 0.0001$), fracture displacement ($p < 0.005$), pelvic stability ($p < 0.0001$), and vector of injury ($p < 0.01$). Nine patients underwent pelvic angiography, three required pelvic embolization, seven had intra-abdominal hemorrhage that required laparotomy, and eight developed a coagulopathy.
Poole, 1994	Emergency Department/ Intensive Care Unit	Retrospective Review	348	63% male, average age 31 years old, 65% motor vehicle collisions, 9.2% isolated pelvic injury - all others associated with other injuries, 28 died (8% mortality), 40% died of hemorrhage, only 4 died of pelvic hemorrhage (14% of deaths), authors conclude that pelvic injuries can be complex but are often simple and not life threatening
Schwed, 2021	Emergency Department	Retrospective Review	1456	The sensitivity and specificity for FAST in patients with pelvic fracture was 85.4% and 98.1%, respectively. The positive predictive value and negative predictive value were 78.4% and 98.8%, respectively. The false positive rate was 1.1%. FAST exams in the setting of pelvic trauma remain highly accurate.
van Vugt, 2006	Review article	Non-systematic literature review	N/A	Describes significant bleeding from pelvic fractures, importance of binding, reviews splinting: pelvic wrap, C-clamp, external fixation, as well as surgical techniques of pelvic packing, angiography and embolization and definitive treatment. Provides algorithm.
White, 2008	Emergency Department, Operating Room, Intensive Care Unit	Systematic review	N/A	Bleeding pelvic fractures that result in instability have mortality of 40%. Because of force need for pelvic fracture, lots of associate injuries, mortality usually due to extra-pelvic sources. Whole blood should be used, pelvic binding used. Use arteriography and embolization is best, can use external fixation or pelvic packing for temporalization. Unstable fractures with hemodynamic instability represent <10% of all pelvic fractures at Level 1 trauma centers.

(*Continued*)

Table 2. Continued.

Author, year	Setting	Article type	# Subjects	Study description and key findings
Effect of pelvic binders on the need for blood transfusion or surgical intervention for hemorrhage				
Agri, 2017	Single trauma center (Switzerland)	Retrospective Review	240	No association between the use of pelvic binders or arterial angio-embolization and survival was observed in this cohort of patients with pelvic fractures. Type C fractures more often associated with falls, Type A or B fractures more often associated with road traffic accidents.
Bangura, 2023	Emergency Department, EMS	Retrospective Review	162	Pelvic binders associated with less hospital admission time, no statistical difference in mortality, packed red blood cell units transfused, or vital signs. 85 (52.8%) suspected injuries by EMS, only 52 (32.2%) had pelvic binder applied
Berger Groch, 2022	Trauma Registry (Germany)	Retrospective Review	9,910	1,103 patients had relevant pelvic trauma. Only 41% of patients with pelvis fracture received PCCD in the field. PCCDs applied more often in patients with severe pelvic trauma according to ISS and AIS-pelvis as well as deterioration of circulatory status. PCCDs did not reduce the need for blood transfusion or reduce mortality.
Flint, 1979	Emergency Department, Interventional Radiology, Operating Room	Retrospective Review	40	Patients were placed in MAST as the primary intervention. They lost less blood, 4000 vs 6200 mL (no MAST, otherwise treatments identical) in the first 18 h. The MAST was left in place an indeterminant amount of time, appears to be at least 14 h and as long as 48. Bleeding stopped with just MAST in 9/10 patients, the 10th required pelvic angioembolization.
Fu, 2013	Pre/post interfacility transfer use of PCCDs	Retrospective Review	585	Patients who received PCCD (sheet or commercial device) before transfer vs those who received PCCD after transfer. compared vital signs, demographics, abbreviated injury score, ISS, intensive care unit length of stay, total units of blood transfusion, and hospital length of stay. 23% had unstable pelvic fracture. no differences between groups (pre/post transfer PCCD) for systolic blood pressure, pelvic AIS, or ISS. Lower blood transfusion for pre-transfer PCCD group, and shorter intensive care unit length of stay and hospital length of stay. Findings were also true for patients with stable pelvic fractures who received pre/post transfer PCCDs.
Ghaemmaghami, 2007	Emergency Department	Retrospective Review	236	Patients with pelvic fractures and risk factors for pelvic bleeding (shock, grade 2 or 3 fracture) had binders placed in emergency department and kept in place for 24–72 h. Binders had no effect on the in-hospital mortality rate, need for pelvic angioembolization to control hemorrhage, or 24-h transfusion requirement. Slightly underpowered study, also possible patients with binder may have had worse outcomes without binder. Impossible to tell.
Hsu, 2017	Emergency Department	Retrospective Review	56	Early PCCD had shorter hospital and intensive care unit stays, improved survival and lower blood transfusion volume despite higher trauma scores.
Rungsinaporn, 2022	Emergency Department	Retrospective Review	30	Applied PCCD to patients with GCS <13, systolic blood pressure <90, fall from >6 m, injury to multiple vital organs, and positive pelvic compression test. Compared transfusion requirements between patients who received a PCCD prior to imaging vs historical patients who received PCCD after imaging. 15 patients in each group. PCCD left in place for 24 h or prior to definitive fixation. Pre-imaging PCCD placement associated with lower transfusion need (0.8 units vs 2.4 units, $p = 0.008$). No difference in hospital length of stay. Eight patients in early PCCD underwent surgery, 4 in late PCCD underwent surgery. Findings comparable to Hsu et al that found PCCD before definitive management had lower transfusion requirement. Study is biased, as early PCCD group had more surgery, and authors did not report time interval between PCCD placement and surgical fixation. Possible that early surgical fixation resulted in less transfusion requirement than PCCD placement did.
Schweigkofler, 2021	EMS, Emergency Department	Retrospective Review	64	No statistically significant difference in terms of injury severity or probability of survival. No statistically significant difference in risk for massive transfusion between binder and no-binder groups, no significant difference in hospital mortality. Study was "unable to identify any blood-saving effects with application of a pelvic binder in patients with unstable pelvic ring fractures."
Trentzsh, 2024	EMS	Retrospective Review	5880	Overall unstable pelvic ring fracture incidence was 9% and binder use increased over time (7.5% to 20.4%). Of all cases with unstable pelvic ring fracture, 40.2% received a binder. Of all cases with binder application, 61% had no pelvic injury at all. Hospital mortality with binder was 1% lower than predicted but failed statistical significance (0.95 vs 1.04, $p = 0.101$). 1,860 propensity score matched pairs were analyzed: there was no difference in mortality or transfusion requirements.

EMS: Emergency Medical Services; GCS: Glasgow Coma Score; GEMS: Ground-based Emergency Medical Services; HEMS: Helicopter-based Emergency Medical Services; ISS: Injury Severity Score; MAST: Military Anti-Shock Trousers; NPV: Negative Predictive Value; OR: Odds Ratio; PCCD: pelvic circumferential compression device; SAM sling: commercial brand of pelvic binder; T-POD: commercial brand of pelvic binder.

Table 3. The relationship of pelvis fractures, pelvic binders, and mortality.

Author, year	Setting	Article type	# Subjects	Study description and key findings
impact of pelvis fractures on mortality				
Abboud, 2021	Emergency Department	Retrospective Review	127	11.8% of patients with high energy blunt mechanism pelvic ring injury had intra-pelvic arterial injury. Patients with intra-pelvic arterial injury were more likely to have prehospital hemodynamic instability and to need blood transfusion within 24 h but did not have worse mortality.
Abdelrahman, 2014	Qatar Trauma center	Retrospective Review	333	Single center retrospective review of trauma patients at Qatar's only Level 1 trauma center. Pelvic fractures are associated with higher early mortality.
Ashkal, 2021	GEMS, Emergency Department	Retrospective Review	129	Young-Burgess classification was most accurate in predicting mortality. A pelvic binder was applied in 34% of pelvic fracture patients, 24.8% of which were applied post-computed tomography scan. 7.2% had a binder placed by EMS. 12% of all pelvic fracture patients died. 33% died of traumatic brain injury. 26.6% died in the emergency department or operating room. In 73% of the deaths a binder was not applied, 54% of those were hemodynamically unstable.
Burkhardt, 2012	Emergency Department, Germany	Retrospective Review	402	Primary focus is on fracture type and associated injury severity. Mean ISS was 25.9, and the mean of patients with ISS ≥16 was 85.6%. The fracture distribution was: 19.7% type A, 29.4% type B, 36.6% type C, and 14.3% isolated acetabular and/or sacrum fractures. Compared to type A fractures Type B/C had consistently worse vital signs that necessitated a higher volume of fluid and blood administration in the prehospital and/or the trauma-room setting. Type B/C fractures were also related to a significantly higher presence of concomitant injuries and higher ISS, longer ventilation and intensive care unit stays, increased rate of multiple organ dysfunction syndrome, sepsis, and increased rate of mortality, at least for the type C fractures. Approximately 80% of the dead sustained Type B/C fractures.
Fox, 1990	Emergency Department	Retrospective Review	175	Mortality was 16% (in 1983-–86). 43.5% had open fractures. Risk factors for mortality included age, admission blood pressure, other injuries, and open pelvic fracture.
Gabbe, 2011	Australian (Victoria) trauma registry	Retrospective Review	348	Mortality rate 19%, patients >65 had higher odds of mortality, prehospital hypotension and hypotension on emergency department arrival also predictive of mortality.
Gottfried, 2024	EMS/Emergency Department	Retrospective Review	244	Registry patients from 1997–2021. In-hospital mortality occurred among 18 (7.4%) patients, all with non-isolated fractures.
Greco, 2019	HEMS, GEMS, Emergency Department	Guidelines and Consensus Documents	N/A	American College of Obstetrics and Gynecology Guidance document. Pelvic fractures confer a higher mortality on mother and baby. Fractures may be treated invasively or noninvasively. Pelvic fractures are not normally an indication for cesarean section.
Hamada, 2018	Emergency Department (France)	Retrospective Review	3675	Demonstrated that traumas with any of the following (Shock Index ≥ 1, mean arterial blood pressure ≤ 70 mmHg, point of care hemoglobin ≤ 13 g/dl, unstable pelvis and prehospital intubation) correlated with packed red blood cell transfusion in the trauma room, or transfusion ≥ 4 units in the first 6 h, or lactate ≥ 5 mmol/L, or immediate hemostatic surgery, or interventional radiology and/or death from hemorrhagic shock.
Heim, 2014	Emergency Department, HEMS, GEMS (Switzerland)	Systematic review	1.599	Review of trauma patients across 12 Swiss trauma centers over a 5-year period. Blunt trauma representative of predominant injury pattern. Increased rates of pelvic/extremity injuries as compared to German 10-year study (40% vs 31.3%). Mortality rates were 50% higher in study hospitals compared to English, Dutch, and German populations (25% vs 13%, 22%, and 19.3%, respectively). Core conclusion of the article advocates for development of regional trauma systems to reduce overall system mortality, as seen in other systems that have a well-organized regionalized trauma system.
Kleber, 2021	EMS, Emergency Department (Germany)	Combined Retrospective and Prospective Observational Study	91 in retrospective arm 36 in prospective arm	Retrospective arm used autopsy to determine cause of death, including causes attributable to unstable pelvic fractures. Unstable pelvic injury was shown to be the leading source of bleeding in only 19% of cases. Leading causes of bleeding were thoracic, peri-pelvic, hepatic, aortic rupture, and cardiac destruction. Prospective arm evaluated application of PCCDs to cadavers with documented unstable traumatic pelvic injuries.
Mcmurty, 1980	Emergency Department	case series, case report	79	19% overall mortality in 1980, 60% if concomitant neurologic injury. 96.2% had both anterior and posterior fractures. 80% had posterior ring disruption. 48.1% presented in shock, 84.81% required transfusion with an average of 11 units per patient, 24 for non-survivors and 7 for survivors, and 15.5 units for posterior disruption vs 5.9 for anterior disruption. Major cause of death was hemorrhage & head injury.
Parreira, 2000	Emergency Department (Brazil)	Retrospective Review	103	Evaluated patients from 42 month-period (exact timeframe not reported), 50% pedestrian vs vehicle, 19% mortality. Age >40 years ($p = 0.02$), "shock" upon admission ($p = 0.002$), a GCS < 9, Head AIS > 2 ($p < 0.001$), Chest AIS > 2 ($p = 0.007$), and abdominal AIS > 2 ($p = 0.03$) all correlated with increased mortality. The outcome of patients with pelvic fractures due to blunt trauma correlates with the severity of associated injuries and physiological derangement on admission rather than with characteristics of or the type of fracture.

(*Continued*)

Table 3. Continued.

Author, year	Setting	Article type	# Subjects	Study description and key findings
Poole, 1991	Emergency Department	Case Series	236	Average age 31.5 years, average ISS was 21.3, average blood requirement was 5 units, and average length of stay was 16.8 days. 152 patients (64.4%) were motor vehicle collisions, 33 (14%) were auto vs pedestrian, 16 (6.8%) had crush injuries, 12 (5.1%) each had either motorcycle accidents or falls, and 11 (4.6%) had miscellaneous accidents. 18 patients (7.6%) died, with 7 (38.9%) deaths due to hemorrhage. Only one death was caused by pelvic hemorrhage. ISS was correlated with indices of severity of pelvic fractures such as fracture site ($p < 0.0001$), fracture displacement ($p < 0.005$), pelvic stability ($p < 0.0001$), and vector of injury ($p < 0.01$). Nine patients underwent pelvic angiography, three required pelvic embolization, seven had intra-abdominal hemorrhage that required laparotomy, and eight developed a coagulopathy.
Poole, 1994	Emergency Department/ Intensive Care Unit	Retrospective Review	348	63% male, average age 31 years old, 65% motor vehicle collisions, 9.2% isolated pelvic injury - all others associated with other injuries, 28 died (8% mortality), 40% died of hemorrhage, only 4 died of pelvic hemorrhage (14% of deaths), authors conclude that pelvic injuries can be complex but are often simple and not life threatening
Ross, 1988	Emergency Department	Retrospective Review	867	35% of pelvic fractures admitted to the hospital had a systolic blood pressure < 90 with a mortality rate of 59%. Five had both pelvic vascular and intraabdominal sources of bleeding. MAST device was used on 12 patients (25%). Emergent therapy included operative stabilization in four patients, angiographic embolization in four patients, and both external stabilization and embolization in four patients.
Soreide, 2009	Emergency Department (Norway)	Case Series	36	Scandinavian study examining autopsies on pediatric and adolescent trauma-related deaths over 10 years in Norway. 36 autopsies performed, 70% boys, predominantly in the 13–17-year-old age range. Blunt trauma in 92%, chiefly road traffic accidents, 42% being "soft" victims (pedestrian/cyclist). Spring and summertime prevalence. Vast majority succumbed to head injuries, none were due to multi-organ failure. Pelvic fixation in 1/15 patients closely studied. 7/14 patients in cohort with abdominopelvic injuries had AIS = 5, 4/14 had AIS = 4, 2/14 had AIS = 6
Tanizaki, 2014	Emergency Department, Interventional Radiology	Case Series	140	Looking at the time relationship between survival and time to angiography for unstable pelvic fracture patients. Earlier embolization may improve survival.
Tonge et al., 1972	Death registry (Australia)	Retrospective Review	908	This was a review of 908 traffic fatalities compared to previous traffic fatalities study in Australia. Pelvic fractures occurred 21.7% of deaths; 33.2% pedestrians, 15.2% car driver, 13% car passenger, 8% cyclists, 5% motorcycle. Details other breakdown of seat belts, alcohol use, helmets, age/sex.
Tseng, 2020	Level 1 trauma center (Taiwan)	Retrospective Review	37	4.9% of all pelvic fractures were open (37 of 772), with overall mortality rate of 21.6% (8 of 37). Univariate and multivariate logistic regression analyses revealed that the revised trauma score was the single independent predictor of acute mortality. The probability of mortality was 0% and 100% when the score was above and below −2, respectively. This model predicted mortality with an AUC of 0.948 (95% confidence interval 0.881–1.000, $p < 0.01$).
White, 2008	Emergency Department, Operating Room, Intensive Care Unit	Systematic review	0	Bleeding pelvic fractures that result in instability have mortality of 40%. Because of force need for pelvic fracture, lots of associate injuries, mortality usually due to extra-pelvic sources. Whole blood should be used, pelvic binding used. Use arteriography and embolization is best, can use external fixation or pelvic packing for temporalization. unstable fractures with hemodynamic instability <10% of all pelvic fractures at Level 1 center.
Yang, 2014	Emergency Department (Taiwan)	Retrospective Review	49,300	Over a 10-year period, the incidence of pelvic fractures in hospitalized patients in Taiwan ranged from 17.17 to 19.42 per 100,000, and an increasing trend with age was observed. The mean case-fatality rate was 1.6% for females and 2.1% for males; male patients with pelvic fractures had a significantly higher risk of death than female patients. 74.2% of these cases were combined with other injuries. The most common associated injuries were other fractures of the lower limbs (21.50%), spine/trunk (20.97%), or upper limbs (18.18%), followed by significant head injuries (17.59%), intra-abdominal injuries (11.00%), and thoracic injuries (7.20%).
Impact of pelvic binders on mortality				
Agri, 2017	Single trauma center (Switzerland)	Retrospective Review	240	No association between the use of pelvic binders or arterial angio-embolization and survival was observed in this cohort of patients with pelvic fractures.

(*Continued*)

Table 3. Continued.

Author, year	Setting	Article type	# Subjects	Study description and key findings
Bangura, 2023	Emergency Department, EMS	Retrospective Review	162	Pelvic binders associated with less hospital admission time, no statistical difference in mortality, packed red blood cell units transfused, or vital signs. 85 (52.8%) suspected injuries by EMS, only 52 (32.2%) had pelvic binder applied
Berger Groch, 2022	Trauma Registry (Germany)	Retrospective Review	9,910	1,103 had relevant pelvic trauma. Only 41% of patients with pelvis fracture received PCCD in the field. PCCDs applied more often in patients with severe pelvic trauma according to ISS and AIS-pelvis as well as deterioration of circulatory status. PCCDs did not reduce the need for blood transfusion or reduce mortality.
Croce, 2007	Emergency Department	Retrospective Review	3,359	Of patients arriving to an emergency department, 186 (6%) met entry criteria; 93 had external pelvic fixation and 93 had PCCD. There were no differences in age or shock severity. Both 24-h (4.9 versus 17.1 units, p 0.0001) and 48-h transfusions (6.0 versus 18.6 units, p 0.0001) were reduced with pelvic orthotic device. Twenty-three percent of each group underwent pelvic angiography, and 24-h transfusion amounts for those patients were also reduced with PCCD (9.9 versus 21.5 units, $p=0.007$). Hospital length of stay (16.5 versus 24.4 days, $p=0.03$) was less with pelvic orthotic device. Although there was decreased mortality with pelvic orthotic device (26%) versus external pelvic fixation (37%), it was not statistically significant ($p=0.11$). Using inflatable pelvic orthotic device splint had decreased 24- and 48-h transfusion rates, decreased hospital length of stay compared to external pelvic fixation device.
Fitzgerald, 2017	Trauma center (Victoria, Australia)	Retrospective Review	1213	Many interventions initiated during study period - widespread use of pelvic binders appears associated with mortality reduction. Similarly, the proportion of patients arriving at the trauma center with hemorrhagic shock appears lower. However, study was unable to demonstrate a statistically significant or a causal relationship, as binder introduction was part of a multi-faceted, overall effort to reduce pelvic injury mortality.
Ghaemmaghami, 2007	Emergency Department	Retrospective Review	236	Patients with pelvic fractures and risk factors for pelvic bleeding (shock, grade 2 or 3 fracture) had binders placed in emergency department and kept in place for 24–72 h. Binders had no effect on the in-hospital mortality rate, need for pelvic angioembolization to control hemorrhage, or 24-h transfusion requirement. Slightly underpowered study, also possible patients with binder may have had worse outcomes without binder. Impossible to tell.
Pizanis, 2013	GEMS	Retrospective Review	6137	Evaluated outcomes of 207 patients treated with sheet wrapping, pelvic binders or C-clamps. Sheet wrapping had higher mortality rate compared to other methods. Groups were similar in severity. Best outcome in young patients, low ISS, C-clamps. Sheet with higher mortality thought to be due to binders and C-clamps used at higher functioning centers, sheet wrapping taken down during evaluation. Sheets and binders easier and quicker to place.
Reiter, 2024	EMS	Retrospective Review	66	66 patients with unstable pelvic fractures were enrolled between 2014 and 2018. The mean ISS score was 21.9. Pelvic binder usage did not differ significantly between patients with an ISS $<$ or ≥ 16 points. Nine patients (13.6 %) died during hospitalization, with a mean survival time of 8.1 days. The survival rate did not differ significantly between patients with or without a pelvic binder or between those with an ideally placed pelvic binder versus those with a binder outside the ideal range. The ISS score, heart rate, blood pressure at admission, and hemoglobin level were significantly different between the group of patients who died and those who survived, indicating their importance in predicting outcomes.
Schweigkofler, 2021	EMS, Emergency Department	Retrospective Review	64	Compared PCCD vs no PCCD use in in patients with unstable pelvic ring fractures. No statistically significant difference in terms of injury severity or probability of survival. No statistically significant difference in risk for massive transfusion between binder and no-binder groups, no significant difference in hospital mortality. Study was unable to identify any blood-saving effects with application of a pelvic binder in patients with unstable pelvic ring fractures.
Trentzsh, 2024	EMS	Retrospective Review	5880	Overall unstable pelvic ring fracture incidence was 9% ($n=5880$) and binder use increased over time (7.5% to 20.4%). Of all cases with unstable pelvic ring fracture, 40.2% received a binder. Of all cases with binder application, 61% had no pelvic injury at all. Hospital mortality with binder was 1% lower than predicted but failed statistical significance (0.95 vs 1.04, $p=0.101$). 1,860 propensity score matched pairs were analyzed: there was no difference in mortality or transfusion requirements.
Warme, 2002	Military	Case Report	1	MAST can decrease pelvic volume but increases prehospital time and mortality. No survival advantage and increase blood pressure causing worsening extravasation. MAST is associated with compartment syndrome. Case report of patient with sheet applied to pelvis after MAST deflation. Patient did well. Sheet technique was not standard, but it was effective.

AIS: Adjusted Injury Severity Score; EMS: Emergency Medical Services; GCS: Glasgow Coma Score; ISS: Injury Severity Score; MAST: Military Anti-Shock Trousers.

Table 4. Field identification of pelvis fractures.

Author, year	Setting	Article type	# Subjects	Study description and key findings
Ashkal, 2021	GEMS, Emergency Department	Retrospective Review	129	A pelvic binder was applied in 34% of pelvic fracture patients, 24.8% of which were applied post-computed tomography scan. 7.2% had a binder placed by EMS.
Balet, 2023	EMS	Retrospective Review	2790	A binder was used in 387 (13.9%) patients. In the binder group, 176 (45.5%) had an unstable pelvic fracture, 52 (13.4%) a stable pelvic fracture and 159 (41.1%) an injury unrelated to the pelvic region. In the group who did not receive a binder, 214 (8.9%) had an unstable pelvic fracture, 182 (7.6%) had a stable pelvic fracture, and 2007 (83.5%) had an injury unrelated to the pelvic region. The nationwide sensitivity of PCCD application was 45.1% (95% CI 40.1–50.2), the specificity 91.2% (95% CI 90–92.3), with both over- and under-triage rates of 55%. The prevalence of unstable fractures in this population was 14% (390/2790).
Bangura, 2023	Emergency Department, EMS	Retrospective Review	162	85 (52.8%) suspected pelvis injuries by EMS, only 52 (32.2%) had pelvic binder applied.
Berger Groch, 2022	Trauma Registry (Germany)	Retrospective Review	9,910	1,103 patients had relevant pelvic trauma. Only 41% of patients with pelvis fracture received PCCD in the field. PCCDs applied more often in patients with severe pelvic trauma according to ISS and AIS-pelvis as well as deterioration of circulatory status.
Bolt, 2018	Emergency Department	Prospective	35	The inability to perform a straight leg raise, or pain with a straight leg raise, was 91.4% sensitive for a pelvic fracture with a 98.6% negative predictive value. Of the three patients who performed a straight leg raise without reported pain, none were a GCS 15, raising the sensitivity and negative predictive value for this test in patients with a GCS of 15 to 100%.
Omri et al., 2017	GEMS (physicians) (Tunisia)	Prospective	200	61% of pelvic injuries were missed on EMS physical exam, 11% of which were potentially life threatening
Coulumbe, 2024	Emergency Department	Retrospective Review	228	Patients with pelvic fracture in trauma registry. Prehospital under-triage rate was 22.6%. 17.1% had an open-book fracture. 46 patients had a PCCD applied at the referral hospital, of which 26.1% needed adjustment.
Ellerton, 2009	Expert Consensus	Guidelines and Consensus Documents	N/A	International Commission for Mountain Emergency Medicine Consensus Recommendations. Few mountain rescue patients suffer pelvic fracture, <1%. Splinting is recommended if pelvic fracture is suspected. "Springing the pelvis" is not recommended. Splint should stay on until in the hospital.
Hasler, 2012	HEMS (physicians) (Switzerland)	Retrospective Review	433	Cohort study of Swiss HEMS physicians (anesthesia or intensive care unit fellows on a 6-month rotation) compared to diagnosis of injury by emergency department attending. HEMS physicians correctly diagnosed pelvis fracture 48.2% of the time, missed pelvis fracture 51.8% of the time, and over-diagnosed pelvis fracture 49.1% of the time.
Jarvis, 2020	Emergency Department	Survey	40	Of 158 United States Level 1 trauma centers, 25% responded to survey. Widespread use of in-hospital and prehospital PCCD at United States level 1 trauma centers, however prehospital PCCDs not applied to all suspected pelvic fractures. 77% of survey respondents indicated paramedic agencies serving their hospital trained on prehospital placement of PCCDs on all suspected pelvic fractures. Most follow Eastern Association for Surgery of Trauma (EAST) guidelines. Describes Western Trauma Association (WTA) and World Society of Emergency Surgery (WSES) guidelines.
Kirves, 2010	Emergency Department (Helsinki Finland)	Retrospective Review	422	Accuracy of EMS vs emergency department-detected injuries to different body regions, including the pelvis. Inter-rater reliability (kappa score) between prehospital and emergency department exams for identifying pelvic fracture were very low: Prehospital Physician − 0.4 (0.26–0.53); Paramedics − 0.3 (0.11–0.48) [Kappa 0.4–0.59 moderate, 0.60–0.9 substantial, 0.8 outstanding]. The ability of paramedics and prehospital physicians to find and document injuries did not significantly differ.
Kuner, 2021	EMS, Emergency Department (Switzerland)	Retrospective Review	77	Included consecutive patients admitted to trauma resuscitation room of a Level I trauma center in Switzerland from 2016 to 2017. Assessed frequency of PCCD placement, correctness of placement, and for PCCD-related iatrogenic injuries. Of 730 total trauma patients, 82 (11%) had pelvic fractures, 5 patients excluded due to fragility fracture or subacute fracture, leaving 77 patients for review: all due to blunt trauma; 26 (34%) had PCCD placed, 24 by EMS; 18 (69%) T-POD, 8 (31%) SAM sling; 10 (13%) correctly received PCCD based on fracture pattern, 8 (10%) missed opportunities (should have had PCCD placed), 43 (56%) did not receive PCCD due to absent indications, and 16 (21%) received PCCD despite absent indications.
Lee, 2007	HEMS, GEMS	Systematic review	N/A	Clinical exam is unreliable and possibly harmful when evaluating pelvic fractures. Patients should be moved *via* scoop stretcher and minimize/eliminate log rolling
Lerner, 2013	EMS	Prospective	10,617	Likelihood ratio of prediction of trauma center need *via* EMS identified pelvic fracture is 1.9 (1.3–2.9) versus LR of hospital identified pelvis fracture by ICD9 is 6.2 (4.9–7.9), which is indicative of the need for a trauma center. There is a need to identify other signs predictive of pelvic fracture in the prehospital setting. EMS correctly identified 18% of pelvis fractures, missed 82% of pelvis fractures, and over-diagnosed pelvis fractures 1% of the time. Per Table 4- EMS 18% sensitive and 98% specific with identifying pelvis fracture. Due to difficulty identifying pelvic fractures in the field, article recommends reconsidering whether pelvic fracture should be used as an indicator for trauma center need.

(*Continued*)

Table 4. Continued.

Author, year	Setting	Article type	# Subjects	Study description and key findings
Linn, 1997	HEMS (physicians) (Israel)	Systematic review	186	Study occurred from 1987–1989. 195 evacuees, 87% men, 17.4% children, 49% aged 18–22 years, 31% aged 22–55, 3/195 were age > 55. Nine excluded so final study was 186 patients. Flight physicians were more likely to miss important injuries to pelvis (15.8%). 7/19 pelvic injuries were not recorded by flight physician. Vital signs measurements were poorly executed in nearly all cases, likely due to environmental factors of noise, vibration and harshness.
Lustenberger, 2016	EMS (Germany)	Retrospective Review	7201	Discusses accuracy of EMS detection of pelvic fractures, description of missed pelvic fractures, risk-factors for missed pelvic fractures. A significant proportion of severe pelvic fractures type B and C were not suspected in the prehospital setting.
McCreary, 2020	GEMS	Retrospective Review	376	There were 376 patients with EMS binders on at hospital arrival. Pelvic fractures were diagnosed in 137 patients (36.4%). Of these, 39 (28.5%) were hemodynamically normal and 98 (71.5%) were hemodynamically abnormal. Of those with fractures, 40 patients (29.2%) required pelvic intervention within 24 h of admission; of these 32 (80%) were hemodynamically abnormal. As a test for pelvic fracture requiring intervention within 24 h, abnormal prehospital hemodynamics had a sensitivity of 80% (95% CI 0.64–0.91), specificity of 32% (95% CI 0.27–0.38) and NPV of 93% (95% CI 0.88–0.96). Combined with absence of a major mechanism of injury, normal hemodynamics had a sensitivity 100%, specificity 51% (95% CI 0.36–0.66) and NPV of 100% for pelvic intervention within 24 h.
Melamed, 2007	Military - Israeli combat casualties	Guidelines and Consensus Documents	Consensus guideline	Israeli Defense Force Clinical Guideline. "Any victim experiencing pelvic pain following high-energy mechanism of injury should be assumed to have an unstable pelvic fracture and should undergo (sheet-based) PCCD."
Mota, 2023	EMS	Retrospective Review	634	634 patients with pelvic injuries were identified, of whom 392 (61.8%) had pelvic ring injuries and 143 (22.6%) had unstable pelvic ring injuries. HEMS personnel suspected a pelvic injury in 30.6% of the pelvic ring injuries and 46.9% of the unstable pelvic ring injuries. A binder was applied in 108 (27.6%) of the patients with a pelvic ring injury and in 63 (44.1%) of the patients with an unstable pelvic ring injury. HEMS prehospital diagnostic accuracy measured in pelvic ring injuries alone was 67.1% for identifying unstable pelvic ring injuries from stable pelvic ring injuries and 68.1% for binder application.
Mulholland, 2008	HEMS (Victoria, Australia)	Prospective	207	Evaluated paramedic's prediction of major injuries to body regions and overall severity compared to patient outcomes. Paramedics ranked injuries to each body region (head, thorax, abdomen/pelvis) as mild, moderate, severe, or no injury, and overall status as minor, moderate, or severe. 62.3% of cohort was defined as "major trauma," mostly blunt (96.1%), motor vehicle collisions 49.3%. Paramedics were unable to reliably identify severe injury to individual body regions (Sensitivity, Specificity: Head – 57.6%, 93.5%; Thorax – 44.7%, 98.3%; Abdomen – 38.5%, 96.0%). Paramedics tended to over-triage (72%, though 68% of those patients still met triage guidelines directing patients to a major trauma center. Estimating the severity of injury to individual body regions does not seem to be a useful method for improving accuracy of prehospital triage of trauma patients, however prehospital prediction of patients likely to require a major trauma center based on global injury severity assessment proved to be a highly sensitive method.
Muller, 2024	EMS	Retrospective Review	39	In 22 of 39 (56.4%) patients with an unstable pelvic fracture a pelvic binder was applied prehospital. A pelvic binder was applied in 19.4% of patients without an unstable pelvic fracture. 40% of pelvic injuries were unrecognized in the prehospital setting.
Nabaweesi, 2008	Pediatric Emergency Department	Retrospective Review	14,908	Johns Hopkins Level 1 pediatric trauma center, trauma admits from January 1990–December 2005. Factors that predict potential for pediatric pelvic fractures. Blunt pelvic trauma occurred in <2% of all trauma admissions. Findings are of somewhat limited use in the EMS setting (predictive factors include age 5–14, pedestrian struck by car, occupant of motor vehicle, and being Caucasian)
Okada, 2020	N/A	Systematic review	20 studies included	49,043 patients collectively across the 20 included studies, including 8300 (16.9%) with pelvic fractures. Median prevalence of pelvic fracture was 10.5%. Overall quality of included studies was low, and there was significant heterogeneity especially with regard to level of consciousness. Most studies set in emergency departments. "Overall clinical utility of physical examination depends on the prevalence of pelvic fracture, threshold probability, and patient's consciousness." "In the situation where the patient is strongly suspected as an unstable pelvic fracture, the net-benefit is subtracted by harm of adverse events (like bleeding that is worsened by exam)." Physical exam "may be" useful as a screening tool in resource limited environments in patients with impaired consciousness.
Pehle, 2003	Emergency Department (Germany)	Prospective	979	During a 45-month period involving 1160 patients, 979 were included in analysis. 928 had negative examination for clinical stability of the pelvis, 51 had positive examination findings. Those with positive pelvic findings had higher injury severity score, more shock, lower initial systolic blood pressure, lower initial hemoglobin, and higher rate of severe chest and abdominal injuries. 43 fractures were missed on exam in the 928 "negative findings" group. Physical exam had a 44% sensitivity and 98% specificity for detecting pelvis fracture. Clinical exam cannot reliably rule out surgically significant pelvic fractures (20%) in the severely injured and intubated blunt trauma patient.

(*Continued*)

Table 4. Continued.

Author, year	Setting	Article type	# Subjects	Study description and key findings
Pierrie, 2021	EMS	Prospective	43	Identification of pelvic fractures in the field remains a challenge. However, a scalable training model for appropriate binder placement was successful without secondary injury to patients.
Sauerland, 2004	Emergency Department	Systematic review	5454	Sensitivity & sensitivity of pelvis X-ray in detecting pelvic fractures was 90%, nearly 100% in patients with a GCS >13. 49 (11.11%) missed fractures out of 441 total fractures, only 3 (0.7%) were clinically significant.
Schwed, 2021	Emergency Department	Retrospective Review	1456	The sensitivity and specificity for FAST in patients with pelvic fracture was 85.4% and 98.1%, respectively. The positive predictive value and negative predictive value were 78.4% and 98.8%, respectively. The false positive rate was 1.1%. FAST exams in the setting of pelvic trauma remain highly accurate.
Schweigkofler, 2018	Emergency Department	Prospective	254	Manual stability testing of the pelvis is not sufficient by itself to help identify unstable pelvic fractures. Low sensitivity for detecting unstable fractures, stability testing performed in <66% of patients in the study - suggesting decisions were made to splint pelvis independent of stability testing. Mechanism of injury and indirect clinical signs are more predictive of unstable pelvic injuries, with presence of more signs being more predictive. Authors recommend early prehospital application of pelvic splint based on mechanism of injury and physical examination independent of pelvic-stability testing.
Shlamovitz, 2009	Emergency Department	Retrospective Review	115	Retrospective review of 1502 trauma patients, 115 identified with pelvis fractures, 34 of them classified as unstable. Unstable pelvic ring on physical examination had a sensitivity and specificity of 8% (95% CI 4–14) and 99% (95% CI 99–100), respectively, for detection of any pelvic fracture and 26% (95% CI 15–43) and 99.9% (95% 99–100), respectively, for detection of mechanically unstable pelvic fractures. The sensitivity and specificity of pelvic pain or tenderness in patients with Glasgow Coma Scale >13 was 74% (95% CI 64–82) and 97% (95% CI 96–98), respectively for diagnosing any pelvic fractures, and 100% (95% CI 85–100) and 93% (95% CI 92–95), respectively for diagnosing of mechanically unstable pelvic fractures. The sensitivity and specificity of the presence of pelvic deformity were 30% (95% CI 22–39) and 98% (95% CI 98–99), respectively for detection of any pelvic fracture and 55% (95% CI 38–70) and 97% (95% CI 96–98), respectively for detection of mechanically unstable pelvic fractures. study suggests that blunt trauma patients with Glasgow Coma Scale >13 and without pelvic pain or tenderness are unlikely to suffer an unstable pelvic fracture.
Spering, 2024	Emergency Department	Retrospective Review	467 in derivation group 9227 in validation group	467 blunt pelvic trauma patients identified in single-center patient records (ISS>/=16 and AIS pelvis >/=3). 24 patients (5.1%) also diagnosed with relevant vascular injury. Despite patients having obvious mechanically unstable pelvic fracture and "some kind of hemodynamic instability," only 25% of patients with peri-vascular injury had a pelvic binder placed by EMS. 100% of patients who died had pelvic binder placed. Vascular injuries in combination with pelvic fractures increases mortality rate (17.4%) vs pelvic fractures without vascular injury (10.3%). Physical exam does not provide any information about vascular injury, only about suspected unstable pelvic fracture. Authors developed a clinical score to identify patients with pelvic fracture being at risk of a concomitant significant vascular injury. Score relies on clinical findings that can be obtained in the prehospital setting. Study does not provide proof that application of a pelvic binder would have made a difference in patient's outcome. However, use of the score can aid in decision-making and accelerated the disposition of the patient to a major trauma center.
Trentzsh, 2024	EMS	Retrospective Review	5880	Overall unstable pelvic ring fracture incidence was 9% ($n = 5880$) and binder use increased over time (7.5% to 20.4%). Of all cases with unstable pelvic ring fracture, 40.2% received a binder. Of all cases with binder application, 61% had no pelvic injury at all. Hospital mortality with binder was 1% lower than predicted but failed statistical significance (0.95 vs 1.04, $p = 0.101$). 1,860 propensity score matched pairs were analyzed: there was no difference in mortality or transfusion requirements.
Vaidya, 2016	Emergency Department	Retrospective Review	112	Most PCCD placed after imaging (72%). Only 47% of unstable pelvic fracture received a PCCD. Lateral compression injuries received PCCD 33% of time, and anterior/posterior compression/vertical shear injuries received PCCD 63% of the time. Hemodynamic instability did not impact PCCD placement. Placement of PCCD still missed 37% of anterior/posterior compression and vertical sheer injuries.
van Leent, 2019	HEMS	Prospective	56	Physical exam and manual compression test of the pelvis by HEMS physicians in the field. Pelvic compression exam identified 3/11 pelvic fractures with one false positive. Physical exam should not be relied upon, and binders should be applied to patients with significant mechanism or hemodynamic instability.
Vermeulen, 1999	GEMS (Switzerland)	Case Series	19	Case series of patients with pelvic injuries in Switzerland who were treated with a strap-style PCCD. Use of a pelvic binder strap in field application, demonstrating quick application, ease of use. 19 patients treated with the pelvic strap belt, 13 with diagnosed pelvic fractures, eight with open book fractures, three of which were in shock. No outcome data reported other than "the evolution was positive."

(*Continued*)

Table 4. Continued.

Author, year	Setting	Article type	# Subjects	Study description and key findings
Wohlgemut, 2023	EMS (London EMS Physicians)	Retrospective Review	947	Retrospective review of diagnostic accuracy of potential life and limb threatening injuries by experienced trauma clinicians (prehospital trauma physician). 86 patients in the cohort (9.1%) had a pelvic fracture, 34 (39.5%) unstable. Unstable fractures were correctly diagnosed in 8 patients (Sensitivity 23.5%), missed in 26 patients (false negative rate 76.5%), and incorrectly diagnosed in 8 patients (False positive rate 0.9%). Likelihood of a patient being diagnosed with an unstable pelvic fracture actually having one was 50%.
Yong, 2016	EMS (physicians) (United Kingdom)	Retrospective Review	170	This study retrospectively evaluated the prehospital diagnosis of pelvic girdle injuries in blunt trauma patients. Review of patients found on computed tomography scan to have pelvic girdle injury. The aim was to establish the diagnostic accuracy, i.e., the sensitivity and specificity, of a prehospital physician-led trauma service in the detection of these potentially life-threatening injuries. In this study of a specialist prehospital trauma service, which included patients of all ages, GCS grades and injury severity, a sensitivity of 0.69 (95% CI 0.50–0.85) and a specificity of 0.81 (95% CI 0.74–0.87) was established for pelvic fracture diagnosis. Despite a low threshold for placement of pelvic binders, there was a group of patients, usually with distracting injuries, normal systolic blood pressure and varying GCS scores, who were still misdiagnosed.
Zingg, 2020	GEMS, HEMS (physicians) (Switzerland)	Retrospective Review	552	552 PCCD patients (out of 2366 trauma patients) Pelvic ring injuries present in 105/2366 (4.4%) Also looked at factors associated with increased risk of pelvic ring injury. PCCD placed in 79 (75%) of patients with pelvic ring injury 26 (25%) omitted PCCD. 16% patients who received PCCD actually had a pelvic ring injury, but only 25% of patients with fracture received a PCCD.

AIS: Adjusted Injury Severity Score; EMS: Emergency Medical Services; FAST: Focused Abdominal Sonography in Trauma; GEMS: Ground-based Emergency Medical Services; HEMS: Helicopter-based Emergency Medical Services; ISS: Injury Severity Score; LR: Likelihood Ratio; NPV: Negative Predictive Value; PCCD: Pelvic Circumferential Compression Device.

Physical exam identification of potential unstable pelvic fractures has been shown to have broad ranges of sensitivity and specificity as detailed in Table 8. Multiple authors have questioned the value of pelvic stability testing, noting both false negative and false positive results are common (18,30,53,90,94,97,153). Accurate examination is even more difficult in patients with severe injuries or intubated blunt trauma patients. Age >60 years old and GCS ≤8 are also noted to be risk factors for missed injuries (81). Physical exam findings other than manual testing for pelvic instability have also been investigated: hemodynamic instability and inability to perform a straight leg raise or pain with a straight leg raise are both associated with pelvic fractures (51,73).

Okada and colleagues performed a systematic review and metanalysis of 20 studies involving 49,000 blunt trauma patients [8300 (16.9%) with pelvic fractures] and investigated the diagnostic accuracy of physical examination by physicians *via* inspection and application of various stress testing, for detecting pelvic fractures compared with imaging confirmation (87). The median prevalence of pelvic fracture was 10.5% with a pooled sensitivity of physical examination of 86% and specificity 92%. Based on this, the authors suggest that physical examination may be useful as a screening tool in the field, even in cases involving impaired consciousness. However, in actual field practice physical examination may not prove as useful as desired, as evidenced by several papers (21,30,42,56,64,75,78,83,85).

Pelvic binder application can be used as a proxy for EMS clinician examination in identifying pelvic fractures and suggests that EMS PCCD application is poorly predictive of the presence or absence of pelvis fractures. One study found that PCCDs were placed in 13.9% of patients, of which 45.5% had unstable pelvic fractures, 13.4% had stable fractures, and 41.1% had comorbid injuries unrelated to the pelvis (30). Of patients with confirmed pelvis fractures who did not receive a PCCD, 8.9% had an unstable pelvic fracture, 7.6% had a stable fracture, and 83.5% had comorbid injuries unrelated to the pelvis. With a prevalence of unstable fractures in 14% (390/2790) of the study population, this translated to a nationwide sensitivity of PCCD application of 45.1%, specificity of 91.2%, and both over- and under-triage rates of 55%. Similarly, a Swiss EMS physician study found that only 16.6% of patients who received a PCCD actually had a pelvis fracture, while 75% patients with a fracture received a PCCD (98). Several other studies have found significant rates of under- and over-triage (21,42,56,64,75,78,83,85).

The poor performance of prehospital physical exam in identifying pelvic fractures has led some authors to recommend against mechanical stability testing of the pelvis, especially considering manual compression of the pelvis has the potential to worsen an unstable fracture (36,79,120,153). Due to the unreliable nature of prehospital physical examination, mechanism of injury may be a more relevant factor influencing the decision to use a PCCD (90,94,130,146). However, using mechanism of injury alone as a criterion for PCCD application is a very liberal approach that will likely lead to significant over-use of PCCDs and distract EMS clinicians from more relevant interventions. Further, mechanisms evolve. Some historical motor vehicle mechanism of injury characteristics including dashboard intrusion, steering wheel deformity, and "irreparable vehicles," were suggested to increase clinician suspicion for pelvis fracture but are based on 1990s data unlikely to be as relevant in today's vehicles (7) (Figure 2).

Table 5. Prehospital splinting interventions for suspected unstable pelvis fractures.

Author, year	Setting	Article type	# Subjects	Study description and key findings
Audretsch, 2021	Emergency Department	Retrospective Review	120	Pelvic binder was significantly faster to apply than C-clamp applied in the operating room (5 vs 60 min) and was faster to bleeding control. C-clamp trended toward more complications, a higher mortality rate due to severe bleeding, and a higher number of total transfusions. However, only the time to application and bleeding control were statistically significant between ED-applied PCCD and operating room-applied C-clamp.
Bailey, 2021	Military	Technical description	30	Improvised binder with malleable SAM splint & tourniquet or malleable SAM splint & cravats applied the same amount of force as a commercial binder and may be a viable alternative in a resource-depleted environment
Bakhshayesh, 2016	Emergency Department, Operating Room, Intensive Care Unit	Systematic review	16	PCCDs are widely used in initial management. Evidence suggests reduces disrupted pelvic rings. Hemorrhagic source and physiological effectiveness of PCCD needs more study. Short term benefit (mean arterial pressure, reducing space) clear, but long term (mortality, length of stay) unclear. Avoid prolonged use.
Bottlang, July 2002	Cadaver	Cadaver	7	Prototype strap-style circumferential pelvic compression device was placed on 7 cadavers with induced pelvic fractures at different anatomic locations to determine best location and optimal strap tension to correct symphysis diastasis. This was a prototype of the SAM pelvic sling splint.
Bottlang, November 2002	Cadaver	Cadaver	7	Pelvic sling at level of greater trochanters required less tension compared to other positions to reduce open-book pelvic fracture. Comparable results to a posterior pelvic C-clamp. Not as good as anteriorly applied external fixators.
Coccolini, 2017	Emergency Department	Guidelines and Consensus Documents	N/A	Presents World Society of Emergency Surgery Guidelines. Classification (minor, moderate, severe). Discusses imaging, labs, examination. Role of pelvic binder: apply early, commercial devices are superior to sheet wrapping.
Cutler, 1971	Military, GEMS, HEMS, Emergency Department	Case Reports	8	1971 study demonstrating use of MAST in 8 patients, 50% of which survived, and demonstrated improved blood pressures while additional resuscitative measures were being employed. Other studies cited within the article suggest that mortality was associated with increased lactic acidosis due to external lower limb compression for extended periods of time. In that study, prolonged use of MAST led to increased mortality in study animals. The degree of external compression seemed to correlate with the degree of rise in arterial pressure.
David et al., 2013	Emergency Department, Operating Room, Intensive Care Unit	Systematic review	N/A	Early application of PCCD can help decrease pelvic volume and lead to venous compression
DeAngelis, 2008	Cadaver	Cadaver	12	Both sheet technique and commercial T-POD do an effective job at reducing open-book pelvic fractures. Poor study - reports only T-POD is statistically significant but both confidence intervals straddle 0. Also, they use the sheet first and then the T-POD second on the same cadaver so it may be possible the T-POD results are confounded by reduction done by the sheet first.
DeKeyser, 2023	Emergency Department	Retrospective Review	37	10.3% of 398 patients presenting to a Level 1 trauma center had a pelvic binder in place with a minimally displaced lateral compression fracture of the pelvic ring. 37 patients met inclusion criteria. Application of pelvic binder to lateral compression fractures was found to accentuate fracture displacement in 61% (14/23) of patients, with many patient's pelvic displacement completely resolving upon removal of the EMS-placed PCCD.
Flint, 1979	Emergency Department, Interventional Radiology, Operating Room	Retrospective Review	40	Patients were placed in MAST as the primary intervention. MAST patients lost less blood, 4000 mL vs 6200 mL with no MAST (otherwise treatments identical), in the first 18 h. MAST was left in place an indeterminant amount of time, appears to be at least 14 h and as long as 48. Bleeding stopped with just MAST in 9/10 patients, the 10th required pelvic angioembolization.
Frank, 2000	GEMS	Non-systematic literature review	N/A	Use of the MAST suit in the past demonstrated increased mortality in moderately hypotensive (systolic blood pressure 50–90 mmHg) trauma patients, unknown benefits/complications in severely hypotensive trauma patients, but author surmises that in severely hypotensive patients, benefits may outweigh risks/complications. Needs more study, including in long transports and those with severe hypotension.
Fu, 2013	Pre/post interfacility transfer use of PCCDs	Retrospective Review	585	Patients who received PCCD (sheet or commercial device) before transfer vs those who received PCCD after transfer. compared vital signs, demographics, abbreviated injury score, ISS, intensive care unit length of stay, total units of blood transfusion, and hospital length of stay. 23% had unstable pelvic fracture. no differences between groups (pre/post transfer PCCD) for systolic blood pressure, pelvic AIS, or ISS. Lower blood transfusion for pre-transfer PCCD group, and shorter intensive care unit length of stay and hospital length of stay. Findings were also true for patients with stable pelvic fractures who received pre/post transfer PCCDs.

(*Continued*)

Table 5. Continued.

Author, year	Setting	Article type	# Subjects	Study description and key findings
Gardner, 2009	Technical report	Technical description	N/A	Description of internal rotation and taping of the lower extremities to obtain pelvic reduction. Technique uses taping of the thighs and feet to achieve internal rotation of the lower extremities, which helps close the pelvis. Technique described is most practical in the hospital but can be adapted to use in EMS setting. Fractures of lower extremities reduced effectiveness of the technique in achieving closed reduction of pelvis fractures.
Garner, 2017	HEMS	Case Report	1	Possible worsening hemodynamics after placement of pelvic compression device. Application of pelvic compression device led to worsening condition by pushing the femur through fractured acetabulum.
al Haj and Deonandan, 2019	GEMS	Systematic review	N/A	Binding represents inexpensive and easily applied emergency strategy with improved outcomes.
Higgins, 2006	HEMS, GEMS	Technical description	N/A	Describes improvised sheet technique for PCCD. Place over greater trochanters, helps with indirect pressure control of posterior pelvic bleeding. Goal is not reduction. Safe, low cost, no complication with short term application, easily removed. Skin breakdown if left on >2 days. Commercial pelvic binders mimic same technique.
Incagnoli, 2019	GEMS, Emergency Department	Guidelines and Consensus Documents	N/A	Recommendations for pelvic binders on all patients with suspected pelvic injury, shock, major bleeding, or altered level of consciousness. Recommendations against sheet wrapping of pelvis.
Jamme, 2018	Emergency Department	Case Report	1	Case report of a 49-year-old male with high-velocity motorcycle collision. Patient received a pelvic binder in the field and underwent computed tomography scan in the emergency department which showed no pelvic injury. Following removal of the pelvic binder the patient still had pain, and an open book fracture requiring surgical intervention was then identified on plain pelvis x-rays: Take home point - pelvic binder may mask pelvic fracture on initial imaging studies.
Karch, 1995	GEMS, HEMS, Emergency Department	Systematic review	398	Comparison between 398 patients in military anti-shock trousers (MAST) cohort to 590 non-MAST cohort. MAST use does not prolong scene time, delay start of surgery, prolong intensive care unit stay, or change mortality rates. These results were for most severely injured patients
Knops, 2011	Cadaver	Cadaver	16	Compared the Pelvic Binder, SAM sling, and T-POD. Similar reduction in all three but T-POD required less pulling force to reduce fractures.
Krieg, August 2005	Emergency Department	Case Report	1	Pelvic compression devices can cause necrosis. Need to release and re-tension in setting of massive fluid resuscitation as edema can cause increased pressure on binding. Remove as soon as possible.
Krieg, September 2005	Emergency Department	Prospective	13	This study evaluated PCCD (belt + buckle device) and significantly reduced pelvic width by 9.9%, similar to definitive fixation of 10%. Results of this clinical trial suggest that the PCCD can rapidly reduce and stabilize open-book type pelvic ring injuries, without causing complications if applied to a range of pelvic ring injuries, including internal rotation type injuries that are prone to internal collapse.
Kuner, 2021	EMS, Emergency Department (Switzerland)	Retrospective Review	77	Retrospective review of patients admitted to trauma resuscitation room of a Level I trauma center in Switzerland. Reviewed consecutive patients from 2016 to 2017. Assessed frequency of PCCD placement, correctness of placement, and for PCCD-related iatrogenic injuries. Of 730 total trauma patients, 82 (11%) had pelvic fractures, 5 patients excluded due to fragility fracture or subacute fracture, leaving 77 patients for review: all due to blunt trauma; 26 (34%) had PCCD placed, 24 by EMS; 18 (69%) T-POD, 8 (31%) SAM; 10 (13%) correctly received PCCD based on fracture pattern, 8 (10%) missed opportunities (should have had PCCD placed), 43 (56%) did not receive PCCD due to absent indications, and 16 (21%) received PCCD despite absent indications. Position was incorrect (too cranially) for 2 (20%) of unstable fractures and 8 (50%) of stable fractures. Incorrect placement occurred for both T-POD (1, 14%) and SAM (1, 33%) in unstable fractures, overall 39% incorrect placement.
Littlejohn, 2015	Wilderness medicine	Guidelines and Consensus Documents	N/A	Article's Table 2 provides a good summary of the principles of pelvic fracture management: no log rolling, use scoop stretcher, low threshold for application of a PCCD, no pelvic manipulation, beware of "distracting injuries" that might distract from identifying/ suspecting a pelvic fracture. Emphasis on recommendations from Lee and Porter papers (also in our library). Legs should be internally rotated and secured in addition to placement of PCCD.
Marmor, 2020	Emergency Department	Non-systematic literature review	N/A	General concept review article centering on emergency department and hospital management of patients with pelvic ring injury and hemodynamic instability. Provides a general discussion of use of pelvic binders in hospital setting. Risk of tissue injury if application pressure exceeds 9.3 kilopascals for more than 2–3 h.

(*Continued*)

Table 5. Continued.

Author, year	Setting	Article type	# Subjects	Study description and key findings
MCCreesh, 2024	EMS, HEMS	Prospective	26	Prospective observational pilot of 26 paramedics in the United Kingdom (13 ground, 13 HEMS) assessed their accuracy of placing a PCCD on a simulated adult trauma patient. Despite nearly 100% accuracy in verbally reporting appropriate landmarks for PCCD placement, only 23% of ground medics and 61.5% of HEMS medics were able to identify the correct landmarks, and only 39% of PCCDs were correctly placed (15.4% GEMS, 61.5% HEMS).
Melamed, 2007	Military - Israeli combat casualties	Guidelines and Consensus Documents	N/A	Israeli Defense Force Clinical Guideline. Any victim experiencing pelvic pain following high-energy mechanism of injury should be assumed to have an unstable pelvic fracture and should undergo (sheet-based) PCCD.
Moss, 2013	EMS (United Kingdom)	Guidelines and Consensus Documents	N/A	United Kingdom EMS consensus statement on packaging of trauma patients. mostly focuses on spinal motion restriction interventions. Reinforces concept of "minimal handling", i.e., coordinate interventions to move patient as few times as possible - prepare pelvic binder and remove clothing prior to log rolling.
Nguyen, 2023	EMS	Retrospective Review	8480	Retrospective review of a United States urban Level 1 trauma center admissions between 2013 and 2017 to generate a model to identify factors predictive of pelvic fracture (and PCCD placement) in the prehospital setting. Multivariate analysis revealed that any two of the following criteria were significantly associated with presence of pelvic injury (2.9 times more likely): blunt injury, hemodynamic instability, impact location, position in vehicle.
Nunn, 2007	Emergency Department	Case Series	7	Application of the improvised pelvic binder is rapid, safe, and easy. Can be placed in setting of other limb fractures. Needs post placement x-ray. Laparotomy and pelvic external fixation can be carried out with it in place.
Pallavicini, 2024	Letter to editor	Correspondence	NA	Authors challenge the findings of Reiter et al, Injury, 2024, arguing that: study size was small, increasing risk for Type II statistical error. Anticipated benefit of binder in this population was small. Study failed to investigate for a relationship between the nature of bleeding (venous, arterial, bone marrow) and its relationship to efficacy of the pelvic binder. Assert that the author's conclusions are not supported by their own data, specifically that "pelvic binder did not reduce blood transfusion requirements" contradicts the author's claim that pelvic binders contribute to minimizing blood loss.
Pap, 2020	HEMS, GEMS, Emergency Department	Systematic review	3890	The process of applying a PCCD is not clearly linked to desirable clinical outcomes and does carry a potential for iatrogenic harm. Nevertheless, the clinical benefits seem to outweigh risks. This best available evidence is of low quality
Pierrie, 2021	EMS	Pilot Prospective Randomized Trial	43	Randomized patients with suspected pelvis fractures to receive PCCD or "usual care." No complications of binder placement were identified. When PCCDs were placed, 8 (40%) had binders placed correctly at the level of the greater trochanter, 2 (10%) were placed too proximally, and 10 (50%) binders were not visualized on x-ray. Two binder group patients and three nonbinder group patients required angioembolization. None required surgical control of pelvic bleeding. Two nonbinder group patients and one binder group patient were readmitted within 30 days and one nonbinder group patient died within 30 days. Conclusion: Identification of pelvic fractures in the field remains a challenge. However, a scalable training model for appropriate binder placement was successful without secondary injury to patients. The model for conducting prospective, randomized trials in the prehospital setting was successful.
Pizanis, 2013	GEMS	Retrospective Review	6137	Evaluated outcomes of 207 patients treated with sheet wrapping, pelvic binders, or C-clamps. Sheet wrapping had higher mortality rate compared to other methods. Groups were similar in severity. Best outcome in young patients, low ISS, C-clamps. Sheet with higher mortality thought to be due to binders and C-clamps being used at higher functioning centers, sheet wrapping taken down during evaluation. Sheets and binders easier and quicker to place.
Pottecher, 2022	EMS (France)	Correspondence	N/A	Discusses "Trauma cognitive prehospital and intrahospital flowcharts on of severe pelvic ring trauma patients." Suggests using this flowchart or thought paradigm improves care of pelvic fractures. Makes several observational statements, not much data to back them up.
Prasarn, June 2013	Cadaver	Cadaver	5	Cadaveric study comparing T-POD and pelvic sheeting showed no significant difference in stability during bed transfers, log-rolling, or head of bed elevation.
Prasarn, May 2013	Cadaver	Cadaver	9	Cadaveric study of surgically created unstable pelvis fractures. PCCD performed with commercial T-POD or sheet. Measurements of pelvic displacement were measured during PCCD placement, log-rolling, bed-to-bed transfer, and elevation of the head of the bed. No differences in motion comparing T-POD to sheet during device application or movements of the cadaver.

(*Continued*)

Table 5. Continued.

Author, year	Setting	Article type	# Subjects	Study description and key findings
Qureshi, 2005	Emergency Department	Case Reports	2	Use of Stuart pelvic harness in two patients. Findings reported include use is unobtrusive and does not hinder resuscitation. Does not preclude later use of an external fixator, Application across pubic symphysis recommended. Concerns included masking of unstable pelvic ring fractures. Two cases of anatomic realignment of pelvic fractures diagnosed on pelvic x-ray in trauma bay. Post application computed tomography scan showed near anatomic realignment, both had improvement in hemodynamics following reduction.
Reiter, 2024	EMS	Retrospective Review	66	66 patients with unstable pelvic fractures were enrolled between 2014 and 2018. The mean ISS score was 21.9. Pelvic binder usage did not differ significantly between patients with an ISS < or ≥ 16 points. Nine patients (13.6 %) died during hospitalization, with a mean survival time of 8.1 days. The survival rate did not differ significantly between patients with or without a pelvic binder or between those with an ideally placed pelvic binder versus those with a binder outside the ideal range. The ISS score, heart rate, blood pressure at admission, and hemoglobin level were significantly different between the group of patients who died and those who survived, indicating their importance in predicting outcomes.
Reyes, 2023	Emergency Department	Prospective	65	65 patients, males over-represented (61.5%), mean age 6 years- old. Evaluated fit of Pediatric Pelvic Binder versus the Sam Pelvic Sling with respect to pediatric age, height, and weight. Inconsistencies with regard to how weight was determined (reported vs actually measured). Main finding was if a child was taller than a length-based tape (Broselow) (greater than 143 cm tall, the SAM pelvic sling could be used, and if child not taller than the length-based tape (less than 143 cm tall), the Pediatric Pelvic Binder could be used. Major issues with the study as it only reported mean and median patient age, not actual findings for individual age-groups typically delineated on pediatric length-based tapes. Huge range of body size between 1 year and 6 years makes this study's findings questionable for children that fit on the tape.
Reynard, 2016	Cadaver	Cadaver	18	Open book fractures were created in 18 cadavers in a controlled manner. Kendrick Extrication Device (KED) with and without a trochanteric belt was applied and x-rays taken. KED with trochanteric belt caused a significant reduction in symphysis diastasis. KED alone can cause worsening of unstable pelvic injuries; Application of a trochanteric band can improve this while maintaining better alignment
Ross, 1988	Emergency Department	Retrospective Review	867	35% of pelvic fractures admitted to the hospital had a systolic blood pressure < 90 with a mortality rate of 59%. Five had both pelvic vascular and intraabdominal sources of bleeding. MAST device was used on 12 patients (25%). Emergent therapy included operative stabilization in four patients, angiographic embolization in four patients, and both external stabilization and embolization in four patients.
Routt, 2002	Emergency Department	Case Report	1	Circumferential pelvic sheeting is small, easily available, transportable, inexpensive, and disposable. No extensive training required. Effective in helping close an open pelvis. May cause ulcers with wrinkled application. Aggressive application can worsen visceral injury or nerve root injuries.
Schaller, 2005	Hospital	Case Report	1	49 year-old male injured while riding bicycle. Unstable pelvis on exam and shorted left leg, hip dislocation determined. Had sheet placed around peri trochanteric region, "drawn snugly across the front and clamped in place, then tightened using a chest tube (presumably with a trocar) to twist it tighter". Anterior-posterior X-ray showed fracture/dislocation of left acetabulum combined with a pelvic ring injury. Post reduction radiograph showed reduction of acetabular fracture - hypotension resolved with reduction of pelvis and fluid resuscitation. Ultimately underwent angiography due to subsequent decreasing blood pressure over 2–3 h. Sheet had been on for 10 h and was them removed. Post injury day two showed erythema where sheet had been twisted and caused increased compression, ultimately developing bullae across symphysis pubis by day 6 and bilaterally across greater trochanters resulting in delay of surgical repair until day 14 and prevented desired approach to repair of left acetabular fracture due to progression of left trochanteric skin breakdown. Skin breakdown still not sufficiently healed by day 24.
Schweigkofler, 2022	Bench research	Technical description	N/A	Technical evaluation of different models of pelvic binders using an artificial pelvic fracture simulator. All devices were found to be effective in stabilizing the pelvic ring, even with posterior fractures.

(*Continued*)

Table 5. Continued.

Author, year	Setting	Article type	# Subjects	Study description and key findings
Scott, 2013	EMS (United Kingdom)	Guidelines and Consensus Documents	N/A	Initial Consensus Document from UK Faculty of Prehospital Care. Pelvic binder is a treatment intervention not a packaging intervention, should be viewed as a hemorrhage control technique and applied early in any trauma patient with unclear cause of hypotension (i.e., no obvious external hemorrhage). Multiple PCCDs on the market, no data to support superiority of one model over another. Provides an algorithm to help guide decision making regarding use of a PCCD (seems mostly based on expert opinion).
Shackelford, 2016	Military (United States)	Guidelines and Consensus Documents	N/A	2016 Tactical Casualty Combat Care Guideline. 2016 review of literature recommended pelvic binder use. Anterior compression (open book) highest mortality type. Pelvic Binders: 1. Stabilize fracture, 2. Control bleeding/improve hemodynamics, 3. Insufficient survival benefit evidence, 4. Risks - unlikely to cause bleeding, can cause pressure ulcers, 5. Weak evidence on best binder.
Simpson, 2002	Emergency Department	Case Reports	2	Two cases describing sheet binding method and calculation of closing pelvic inlet and Symphysis before and after application of sheet.
Spanjersberg, 2009	Review article	Systematic review	17	17 articles included in this review. PCCDs seem to be effective in early stabilization of unstable pelvic fractures - reduce size and associated bleeding. However, prospective data concerning outcomes (mortality and complications-skin) is lacking. No randomized controlled trials included. Unknown if contraindications based on fracture type.
Stover, 2006	Cadaver	Cadaver	10	10 cadavers underwent computed tomography scan to compute pelvic volume. They were then given an open book fracture an average of 6.3 cm in diastasis. Using three mathematical models, they determined pelvic volume increased between 4.5 - 20%, with an average increase in volume across all models of 364 mL.
Suzuki, 2020	EMS	Case Reports	3	Description of adverse effects of application of PCCD on 3 patients. One developed incarcerated bladder with extraperitoneal bladder rupture and also developed a surgical site infection following internal fixation and required multiple debridements. Patient two had PCCD in place for 14 h following embolization for bleeding from superior gluteal artery and sacral artery and ultimately developed bilateral muscle necrosis anterior to the pelvis correlating with the area where PCCD was overlying. Resulted in delayed surgical repair of his fracture, ultimately developing a walking disability. Third patient developed worsening shock following PCCD placement, was ultimately found to have a displaced acetabular fracture and comminuted sacral fracture that was not found until PCCD was removed and an external iliac vein injury was detected. After ligating external iliac vein, patient developed coagulopathy and exsanguination and died 5 h after emergency department arrival.
Tan, 2010	Emergency Department	Case Series	15	Case series of application of the T-POD pelvic stabilizer on patients with prehospital untreated pelvic fracture shortly after presentation to a Level 1 trauma center. Excluded patients that already had a binder applied by EMS. Device was found to decrease pelvic volume and symphyseal diastasis and improve heart rate and blood pressure. In 10 patients with hemodynamic instability and unstable pelvic fractures, application of the T-POD device showed 7 good responses (mean arterial pressure $p = 0.04$), 1 transient response (mean arterial pressure p-not calculated), and 2 poor responses (mean arterial pressure $p = 0.8$.)
Tiziani, 2022	EMS, Emergency Department	Retrospective Review	76	53% had pelvic ring injury, of which 74% were unstable. SAM sling used in 82% of patients, remainder had T-POD device. Correct placement defined as within 5 cm of trochanters Mean degree of misplacement was 57 mm (41–247mm, SD 54.5 mm) 50% of PCCDs were moderately displaced, 21% severely displaced (>100mm) Incorrect placement of PCCD persists despite widespread implementation. Misplacement is always cranially. Misplacement had no effect on preclinical fluids or parameters of resuscitation. This calls into question whether PCCD has clinical impact, as correct or incorrect placement did not have different effects on resuscitation parameters.
Toth, 2012	Emergency Department	Retrospective Review	43	Retrospective analysis of 43 patients with type B-C pelvic fractures at a Level I trauma center emergency department showed that alignment of the pelvis was "improved or perfect" in 68% of cases, and unchanged in 21% of cases on post-PCCD placement radiographs.
van Vugt, 2006	Review article	Non-systematic literature review	N/A	Describes significant bleeding from pelvic fractures, importance of binding, reviews splinting: pelvic wrap, C-clamp, external fixation, as well as surgical techniques of pelvic packing, angiography and embolization and definitive treatment. Provides algorithm.

(*Continued*)

Table 5. Continued.

Author, year	Setting	Article type	# Subjects	Study description and key findings
Vermeulen, 1999	GEMS (Switzerland)	Case Series	19	Case series of patients with pelvic injuries in Switzerland who were treated with a strap-style PCCD. Use of a pelvic binder strap in field application, demonstrating quick application, ease of use. 19 patients treated with the pelvic strap belt, 13 with diagnosed pelvic fractures, eight with open book fractures, three of which were in shock. No outcome data reported other than "the evolution was positive."
Wallner, 2022	WEMS	Technical description	N/A	Survival blankets can be used as improvised pelvic compression devices.
Warme, 2002	Military	Case Report	1	MAST can decrease pelvic volume but increases prehospital time and mortality. No survival advantage and increase blood pressure causing worsening extravasation. Assoc with compartment syndrome. Case report of patient with sheet applied to pelvis after MAST deflation. Patient did well. Sheet technique was not standard, but it was effective.
Wiliamson, 2020	EMS, Emergency Department, (Queensland, Australia)	Retrospective Review	496	Retrospective evaluation of consecutive patients treated in trauma center who had a pelvic binder in place on arrival to emergency department (i.e., placed by EMS). X-rays reviewed for accuracy of pelvic binder placement relative to the optimal placement between the greater and lesser trochanters. 43.5% of PCCDs were sub optimally placed (39% superior, 4% inferior), though most were within 6 cm of proper placement. more misplacement in female patients (63% vs 37% in males). Obesity was not found to negatively impact proper PCCD placement.
Williams-Johnson, 2010	Emergency Department	Guidelines and Consensus Documents	N/A	Pelvic binders are superior to MAST pants.
Wong, 2017	HEMS, GEMS, Emergency Department, Operating Room, Intensive Care Unit	Non-systematic literature review	N/A	Pelvic fractures are associated with other injuries. Between 60 and 80% of patients will also have another musculoskeletal injury, 12% will have urogenital injuries and 8% with lumbosacral plexus injuries. Pelvic binders may be used. Legs should be internally rotated. computed tomography scan modeling has demonstrated that pelvic fractures do not significantly increase the pelvic volume. Binding reduces bleeding by stabilizing the fracture rather than tamponade.

AIS: Adjusted Injury Severity Score; EMS: Emergency Medical Services; GEMS: Ground-based Emergency Medical Services; HEMS: Helicopter-based Emergency Medical Services; ISS: Injury Severity Score; KED: Kendrick's Extrication Device; MAST: Military Anti-Shock Trousers; PCCD: Pelvic Circumferential Compression Device; SAM sling: commercial brand of pelvic binder; SAM splint: commercial brand of malleable extremity splint; T-POD: commercial brand of pelvic binder.

Accurate prehospital identification of all pelvic fractures is not necessary. However, patients with unstable fractures with associated pelvic vascular injury represent a subset of trauma patients that may benefit from earlier field identification. Spering and colleagues derived a prediction score to detect significant pelvic vascular injury in patients with pelvic fractures based on nine factors that could be obtained in the prehospital setting (Figure 3) (92). The odds ratio for pelvic vascular injury was 24.3 for patients who scored ≥3 points compared to patients who scored ≤2 points. The authors acknowledge the limitations of their data including that it provided no proof that application of a pelvic binder would impact patient outcomes and an absence of data regarding long-term outcomes. To our knowledge, this prediction score has not been placed into operational practice in any EMS agency. Therefore, the role of this scoring system for EMS remains unclear.

Prehospital use of PCCDs should be reconsidered given lack of proven clinical benefit including insufficient evidence that PCCDs reduce traumatic hemorrhage or mortality, and potential for iatrogenic injuries.

We reviewed 62 studies that explored the potential benefits and risks of PCCDs and found mixed evidence (Table 5).

Proposed Mechanism of Benefit

The hypothesized benefit of PCCDs is that they reduce the risk for hemorrhage associated with unstable pelvic fractures by reducing pelvic volume, augmenting tamponade, or stabilizing the fracture itself (44,106). In a radiologic review of 16 pelvic fracture patients in whom commercial PCCDs were applied, Kreig found that pelvic width was decreased by the same amount with PCCD placement as definitive stabilization (9.9% vs 10% respectively) (118). A cadaveric study by Knops et al., comparing three commercial PCCDs found similar reduction in all devices (117). A retrospective analysis of imaging in 43 patients with PCCDs applied for pelvic fractures showed that alignment of the pelvis was "improved or perfect" in 68% of cases and unchanged in 21% of cases on post-PCCD placement radiographs (143). However, separate studies by Toth and DeKeyeser showed that pelvic binders placed on lateral compression fractures worsened deformity in 11% and 61% of cases, respectively (108,143). It is important to note that all of these studies focused on mechanical outcomes only and did not address any patient-centered outcomes, so the actual impact of PCCDs remains in question.

Mechanisms of injury are important as they result in different fracture morphology, which have varying rates of associated vascular injury, and some injury patterns may be exacerbated by PCCDs. Pelvic fractures are classified in three types: Type A – stable fractures that do not disrupt the pelvic ring and do not require stabilization; Type B – disrupt the pelvic ring and are rotationally unstable but vertically stable; and Type C – both rotationally and vertically

Table 6. Triage and transport decisions for patients with suspected unstable pelvis fractures.

Author, year	Setting	Article type	# Subjects	Study description and key findings
Carchietti, 2013	HEMS, GEMS	Case Reports	3	Study evaluated the amount of vibration occurring on study subjects in flight. They found very low rates of vibration (both frequency and amplitude) in flight. Authors suggest HEMS transport imparts less vibration than GEMS transport. This "may have beneficial impact on reducing bleeding from unstable pelvic fractures." However, author's assertions are not supported by the provided evidence. Assessment of vibration was limited to a single airframe and aircraft (EC135 helicopter), and the study's findings cannot be extrapolated to other aircraft. It did not assess vibration occurring in ground ambulances, therefore there is no comparison group on which to base the conclusion that HEMS transport imparts less vibration than GEMS transport. Further, the authors provided no evidence or investigation whether vibration during transport had any actual clinical effect on rates of or degree of bleeding attributable to pelvic fractures.
Gabbe, 2011	Trauma Registry (Victoria, Australia)	Retrospective Review	348	Mortality rate 19%, patients >65 had higher odds of mortality, prehospital hypotension and hypotension on emergency department arrival also predictive of mortality compared to patients without hypotension.
Garwe, 2012	GEMS	Case Series	87	Case series at a Level 1 trauma center. Direct transport of geriatric (≥55 years old) patients with pelvic fracture (ring disruption) to a Level 1 trauma center decreased complications in first 2 weeks post injury compared with those transferred into a Level 1 trauma center. Geriatric patients with severe pelvic fractures not sent immediately to a trauma center had increased odds of developing pneumonia and/or systemic inflammatory response syndrome/sepsis compared to those directly sent to a trauma center (odds ratio 3.4; 95% CI.72–16.2). Researchers also concluded 54% increase in incidence of complications in elderly requiring transfer to trauma center (Incidence rate ratio, 1.54, 95% CI.95–2.54).
Gutierrez, 2022	Emergency Department	Retrospective Review	379,890	190,264 patients used in derivation cohort, and 189,626 used in the validation cohort. Pelvic fracture was found to be one of several variables included in a model used to predict the need for trauma patients requiring early laparotomy. Paper acknowledges inherent difficulty in identifying pelvic fracture in the field, making this data element in the model potentially less useful.
Hamada, 2018	Emergency Department (France)	Retrospective Review	3675	It describes prehospital notification of trauma alerts in France. Demonstrated that traumas with any of the following (Shock Index ≥1, mean arterial blood pressure ≤70 mmHg, point of care hemoglobin ≤13 g/dL, unstable pelvis and prehospital intubation) correlated with packed red blood cell transfusion in the trauma room, or transfusion ≥4 units in the first 6 h, or lactate ≥5 mmol/L, or immediate hemostatic surgery, or interventional radiology and/or death of hemorrhagic shock.
Incagnoli, 2019	GEMS, Emergency Department	Guidelines and Consensus Documents	N/A	Consensus document from French Society of Anesthesia and Intensive Care Medicine. Recommendations for pelvic binders on all patients with suspected pelvic injury, shock, major bleeding, or altered level of consciousness, and transport to trauma center.
Lerner, 2013	EMS	Prospective	10,617	Likelihood ratio of prediction of trauma center need *via* EMS identified pelvic fracture is 1.9 (1.3–2.9) versus LR of hospital identified pelvis fracture by ICD9 is 6.2 (4.9–7.9), which is indicative of the need for a trauma center. There is a need to identify other signs predictive of pelvic fracture in the prehospital setting. EMS correctly identified 18% of pelvis fractures, missed 82% of pelvis fractures, and over-diagnosed pelvis fractures 1% of the time. Per Table 4- EMS 18% sensitive and 98% specific with identifying pelvis fracture. Due to difficulty identifying pelvic fractures in the field, article recommends reconsidering whether pelvic fracture should be used as an indicator for trauma center need.
McCreary, 2020	GEMS	Retrospective Review	376	As a test for pelvic fracture requiring intervention within 24 h, abnormal prehospital hemodynamics had a sensitivity of 80% (95% CI 0.64–0.91), specificity of 32% (95% CI 0.27–0.38) and NPV of 93% (95% CI 0.88–0.96). Combined with absence of a major mechanism of injury, normal hemodynamics had a sensitivity 100%, specificity 51% (95% CI 0.36–0.66) and NPV of 100% for pelvic intervention within 24 h.
Mulholland, 2008	HEMS, Victoria, AUS	Prospective	207	Evaluated paramedic's prediction of major injuries to body regions and overall severity compared to patient outcomes. Paramedics ranked injuries to each body region (head, thorax, abdomen/pelvis) as mild, moderate, severe, or no injury, and overall status as minor, moderate, or severe. 62.3% of cohort was defined as "major trauma," mostly blunt (96.1%), motor vehicle collisions 49.3%. Paramedics were unable to reliably identify severe injury to individual body regions (Sensitivity, Specificity: Head – 57.6%, 93.5%; Thorax – 44.7%, 98.3%; Abdomen – 38.5%, 96.0%). Paramedics tended to over-triage (72%, though 68% of those patients still met triage guidelines directing patients to a major trauma center. Estimating the severity of injury to individual body regions does not seem to be a useful method for improving accuracy of prehospital triage of trauma patients, however prehospital prediction of patients likely to require a major trauma center based on global injury severity assessment proved to be a highly sensitive method.

(*Continued*)

Table 6. Continued.

Author, year	Setting	Article type	# Subjects	Study description and key findings
Rozenberg, 2017	Emergency Department	Retrospective Review	343,868	Retrospective database review (representing 20% of United States hospitals). 29% of patients (100, 297) admitted to Level I trauma center, 5.7% (5,691) transferred to Level 1 trauma center on a national level, motor vehicle collision patients with pelvis or femur fractures that are transferred to a Level I trauma center do not have higher mortality than those who are direct admits to the Level 1 trauma center despite higher severity of injury and risk of mortality. Pelvis/Acetabular fractures represent approx. 11.5% of transfers to Level I trauma center. By comparison, femur fractures represent 7.8% of transfers
Tazarourte, 2022	EMS (France)	Guidelines and Consensus Documents	N/A	Discussion of French Trauma society cognitive aids and trauma flowcharts
Viel, 2019	Interfacility transfers (Brazil)	Retrospective Review	246	Pelvic girdle/extremities are the most severely injured body region for interfacility transfers (75% of cases had pelvic girdle/extremity injury).

CI: Confidence Interval; EMS: Emergency Medical Services; GEMS: Ground-based Emergency Medical Services; HEMS: Helicopter-based Emergency Medical Services; ICD9: International Classification of Diseases version 9; LR: Likelihood Ratio; NPV: Negative Predictive Value.

unstable (see Figure 2). A German trauma registry study found 19.7% of pelvic fractures were type A, 29.4% were type B, and 36.6% were type C (46). Other research reported less frequent rates of unstable fractures, between 9 and 14% (30,42). Abboud et al., found that 11.8% of patients with a high-energy blunt mechanism of injury sustain unstable pelvic fractures with concomitant intra-pelvic arterial injuries. Lateral compression mechanisms account for 8.6% of these cases, while 33.3% were anterior-posterior compression and 23.5% were vertical sheer injuries (5). Type B fractures from anterior-posterior forces may benefit from stabilization with pelvic binders, but Type B fractures from lateral compression forces may be worsened by application of a pelvic binder (108,143). Notably, 10% of trauma patients presenting to a Level 1 trauma center with a pelvic binder in place have lateral compression injuries. Application of a pelvic binder was found to worsen fracture displacement in 61% of these patients, with many patient's fractures reducing to normal anatomic position after removal of the pelvic binder (108).

Hemorrhage Control

Studies that investigated the impact of use of PCCDs on hemorrhage shown mixed results (Table 2). A small retrospective review of 56 patients suggests early PCCD placement results in lower volumes of blood transfusion despite higher injury severity scores (60). Audretsch suggests that pelvic fractures stabilized with PCCDs in the field experienced more rapid bleeding control than those managed with a C-clamp device applied in the operating room (99). A study comparing ED-placed PCCD to operating room-placed external fixators showed that transfusion volume was decreased in the PCCD group (24 h: 5 vs 17 units; 48 h: 6 vs 18 units, $p < 0.0001$), including in patients undergoing pelvic angiography (70). Another study suggests patients receiving an improvised sheet or commercial PCCD prior to interfacility transfer had lower transfusion needs than patients who received a PCCD after arriving at the destination hospital, though only 23% of patients in the study had an unstable pelvic fracture, and patients with stable pelvic fractures who also received a PCCD were also found to have decreased transfusion needs (58). This suggests that there may have been significant confounding by the presence of non-pelvic sources of bleeding in patients who did not receive PCCDs compared to patients that did receive a PCCD, or that PCCDs had a neutral effect and another intervention occurring in parallel with PCCD use was responsible for improved outcomes. Rungsinaporn's investigation of the impact of PCCD placement prior to imaging vs historical controls who received a PCCD after imaging also found that earlier PCCD placement resulted in lower transfusion requirements (61). However, this study was subject to significant bias and confounding, as the PCCD group underwent more surgical interventions and the time interval between PCCD placement and definitive surgical fixation was not reported. It is possible that earlier surgical fixation in the PCCD group was responsible for decreased transfusion needs rather than a direct effect of the PCCD.

Studies showing PCCD-related reduction in hemorrhage or transfusion requirements are contradicted by several studies. Bangura et al., report that PCCDs had no statistical difference in the amount of blood units transfused, however only 32% of eligible patients received an EMS-placed PCCD in their study (21). Trentzsch et al., and Schweigkofler also found no statistically significant difference in transfusion requirements when comparing PCCD use to nonuse (42,62). Another retrospective review of 236 patients with pelvic fractures also found no statistically significant difference in 24-h transfusion requirement or the rate of pelvic embolization for patients with shock or grade 2 or 3 pelvic fractures who had PCCDs placed in the ED (59).

Pelvic Splinting and Mortality Outcomes

Thirty-three manuscripts discussed the relationships between pelvic fractures, use of PCCDs, and mortality, and are summarized in Table 3. While our review found mixed evidence, most studies suggested the use of PCCDs did not confer a survival benefit (21,23,29,42,48,56,59,62,127,137).

Hsu et al.'s retrospective study of 204 poly-trauma patients whose pelvic fractures were stabilized with a PCCD in the field versus in the ED found no statistically significant

Table 7. Special populations with suspected pelvis fractures.

Author, year	Setting	Article type	# Subjects	Study description and key findings
Geriatric				
Cuevas Ostrem, 2021	Registry (Norway)	Retrospective Review	11,403	Description of geriatric Norwegian trauma patients. Geriatric trauma epidemiology. In presence of pelvic/lower extremity injury AIS ≥3 increases with age beginning at age 55–64 years old.
Gabbe, 2011	Trauma Registry (Victoria, Australia)	Retrospective Review	348	Mortality rate 19%, patients >65 years old had higher odds of mortality, prehospital hypotension and hypotension on emergency department arrival also predictive compared to patients without hypotension.
Garwe, 2012	GEMS	Case Series	87	Case series at a Level 1 trauma center. Direct transport of geriatric (≥ 55 years old) patients with pelvic fracture (ring disruption) to a Level 1 trauma center decreased complications in first 2 weeks post injury compared with those transferred into a Level 1 trauma center. Geriatric patients with severe pelvic fractures not sent immediately to a trauma center had increased odds of developing pneumonia and/or systemic inflammatory response syndrome/sepsis compared to those directly sent to a trauma center (odds ratio 3.4; 95% CI .72–16.2). Researchers also concluded 54% increase in incidence of complications in elderly requiring transfer to trauma center (Incidence rate ratio, 1.54, 95% CI .95–2.54).
Leighton, 2020	GEMS, HEMS, Emergency Department, Operating Room, Intensive Care Unit	Non-systematic literature review	N/A	Unstable pelvic fracture is a predictor of massive transfusion in patients over the age of 65 (OR 21.56). Tranexamic acid and prehospital blood transfusion are both safe and effective. Despite equivocal evidence, pelvic binders are the standard of care.
Obesity				
Boulanger, 1992	Emergency Department	Retrospective Review	6368	Obese patients were more likely than non-obese to sustain pelvic fractures from blunt trauma (13.7 v 9%, $p < 0.01$). Similar results when motor vehicle collisions analyzed (14.6 v 10.8%, $p < 0.05$)
Stewart, 2018	HEMS, GEMS, Emergency Department	Systematic review	N/A	Obesity confers a significantly higher mortality overall, increased incidence of pelvic fractures, increased likelihood of binder misplacement.
Pediatric				
Banerjee, 2009	HEMS and Trauma hospital, Intensive Care Unit (London, United Kingdom)	Retrospective Review	44	Retrospective case series of 44 pediatric patients with pelvic fractures who were transported by London HEMS to London Level 1 Trauma Center over 10-year period Most common mechanism - pedestrian vs car; most fractures were stable, even in skeletally immature pelvis; associated injuries to head and other long bone. Seven deceased patients. Isolated pelvic fracture was well tolerated but many pediatric patients had complex injuries and some of those other injuries had high mortality.
Friedland, 1994	Emergency Department	Systematic review	99	Of 433 total pediatric trauma patients in the registry, 99 were reviewed. 22 were excluded who met criteria because they were intubated. 52 of 99 (53%) were given analgesics, 47% were not. 46 of 99 (46%) children had multisystem injuries, and in those who did not, only 62% received analgesics. Head injured patients received analgesics far less frequently than those with isolated fractures. Authors did not find statistically significant differences between study cohorts. Authors recommended further study to determine if, after initial evaluation, a larger proportion of mildly to moderately injured trauma patients with fractures are appropriate candidates for emergency department analgesia. Take home point - it appears children with fractures do not receive adequate analgesic interventions in the emergency department. This might translate to under-use in the prehospital setting as well.
Nabaweesi, 2008	Pediatric Emergency Department	Retrospective Review	14,908	Johns Hopkins Level 1 pediatric trauma center, trauma admissions from January 1990–December 2005. Identified factors that predict potential for pediatric pelvic fractures. Blunt pelvic trauma occurred in <2% of all trauma admissions. Findings are of somewhat limited use in the EMS setting (predictive factors include age 5–14, pedestrian struck by car, occupant of motor vehicle, and being Caucasian)
Reyes, 2023	Emergency Department	Prospective	65	65 patients, males over-represented (61.5%), mean age 6 years old. Evaluated fit of Pediatric Pelvic Binder versus the SAM pelvic Sling with respect to pediatric age, height, and weight. Inconsistencies with regard to how weight was determined (reported vs actually measured). Main finding was if a child was taller than a length-based tape (Broselow) (greater than 143 cm tall), the SAM pelvic sling could be used, and if child not taller than the length-based tape (less than 143 cm tall), the Pediatric Pelvic Binder could be used. Major issues with the study as it only reported mean and median patient age, not actual findings for individual age-groups typically delineated on pediatric length-based tapes. Huge range of body size between 1 year and 6 years makes this study's findings questionable for children that fit on the tape.
Soreide, 2009	Emergency Department (Norway)	Case Series	36	Norwegian study examining autopsies on pediatric and adolescent trauma-related deaths over 10 years. 36 autopsies performed, 70% boys, predominantly in the 13–17 year-old age range. Blunt trauma in 92%, chiefly road traffic accidents, 42% being "soft" victims (pedestrian/cyclist). Spring and summertime prevalence. Vast majority succumbed to head injuries, none were due to multi-organ failure. Pelvic fixation in 1/15 patients closely studied. 7/14 patients in cohort with abdominopelvic injuries had AIS = 5, 4/14 had AIS = 4, 2/14 had AIS = 6
Pregnant				

(*Continued*)

Table 7. Continued.

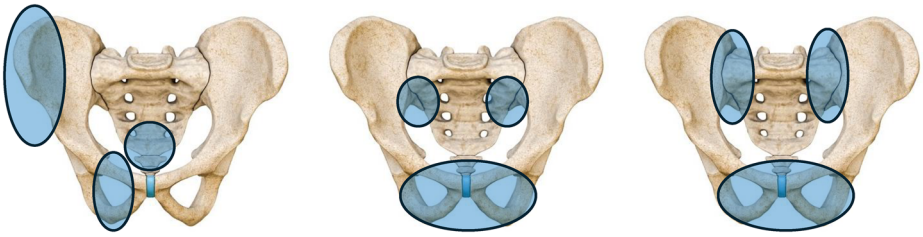
Author, year	Setting	Article type	# Subjects	Study description and key findings
Cannada, 2010	Emergency Department	Retrospective Review	10	1055 patients, of which 65 had orthopedic trauma and 10 had pelvic fractures. In patients with pelvic fractures, there was placental abruption in 30%, with 30% fetal mortality. Pelvic fractures had the highest complication rate of any of the other orthopedic injury subgroups analyzed.
Greco, 2019	HEMS, GEMS, Emergency Department	Guidelines and Consensus Documents	N/A	Pelvic fractures confer a higher mortality on mother and baby. Fractures may be treated invasively or noninvasively. Pelvic fractures are not normally an indication for cesarean section.
Tejwani, 2017	Emergency Department, Operating Room, Intensive Care Unit	Non-systematic literature review	N/A	34–64% of pregnant women are unrestrained at time of collision, and 7% of pregnant women sustain trauma while pregnant. 0.3–0.4% require admission, with a 24% maternal and 50–65% fetal mortality. Transient osteoporosis may occur during the third trimester, increasing the risk of fractures. Advanced Trauma Life Support (ATLS) should be used by a multidisciplinary team and both the mother and fetus should be monitored. No other recommendations relevant to prehospital medicine.

AIS: Adjusted Injury Severity Score; CI: Confidence Interval; GEMS: Ground-based Emergency Medical Services; HEMS: Helicopter-based Emergency Medical Services; OR: Odds Ratio.

Table 8. Reported measures of accuracy of physical exam-detection of pelvis fractures.

Author	Examination setting, clinician, and technique	Cohort	Sensitivity	Specificity	NPV	PPV
Balet, 2023	Prehospital, EMS clinicians, PCCD placement as a proxy for positive physical exam	Unstable pelvis fractures among blunt trauma patients (390/2790), 387 patients with PCCD	45.1%	91.2%	91%*	45%*
Bolt, 2018	Emergency Department, Physicians, Inability to perform a straight leg raise or pain with straight leg raise (any GCS)	Blunt trauma patients with pelvic fracture detected on X-ray (35/328)	91.4%	70.7%*	98.6%	27%
	Straight leg raise + GCS 15		100%	68.5%*	100%	26.9%
Grant, 1990	Emergency Department, Physicians, "Springing the pelvis" with medially-applied force and/or posterior-lateral-applied force	36 patients suspected of fracture, 22 with confirmed fracture on X-ray, 50% motor vehicles, 50% elderly falls	59%	71%	52.5%*	76%*
Lustenberger, 2016	Prehospital, EMS clinicians, Physical exam (details not provided)	7884 prehospital suspected fractures, 7201 with Computed tomography-confirmed pelvis fracture	55.9%	88%	88.7%*	54%*
McCreary, 2020	Prehospital, EMS clinicians, Hemodynamic instability	Abnormal prehospital hemodynamics in patients with pelvis fracture requiring intervention in <24 h (32/40)	80%	32%	93%	12%
		Normal hemodynamics + no major mechanism of injury in patients with pelvis fracture requiring intervention in <24 h (8/40)	100%	51%	100%	4%
Pehle, 2003	Emergency Department, Physicians, Pelvic Ring Stability	Any pelvic fracture in blunt trauma patients (51/929)	44%	98%	58.8%*	96%*
Okada, 2020	Systematic review of physician-based exams	All patients	86%	92%	96%*	91%*
		Patients with GCS ≥13	93%	92%	99%*	59%*
Shlamovitz, 2009	Emergency Department, Physicians, Pelvic Ring Stability	Any pelvic fracture (115/1502)	8%	99%	92%*	40%*
		Unstable pelvic fracture (34/1502)	26%	99%	98%*	38%*
	Pelvic pain or tenderness + GCS >13	Any pelvic fracture	74%	97%	98.8%*	52.7%*
		Unstable pelvic fracture	100%	93%	100%*	32%*
	Pelvic deformity	Any pelvic fracture	30%	98%	29.5%*	71%*
		Unstable pelvic fracture	55%	97%	100%*	41%*
Wohlgemut, 2023	Prehospital, London EMS Physicians, Physical exam (details not provided)	Hospital-confirmed unstable pelvis fracture 34/947 blunt trauma patients (3.6%)	23.5%	99.5%	97.2%	65%
Yong, 2016	Prehospital (United Kingdom) HEMS Physicians, PCCD placement as a proxy for positive physical exam	Computed tomography-confirmed pelvic fractures (26/170), 45 patients with PCCD	69%	81%	93.5%*	39.6%*

*Values not originally reported as part of the source manuscript, these were manually calculated from data in the source manuscripts after-the-fact for this table.
EMS: Emergency Medical Services; GCS: Glasgow Coma Score; HEMS: Helicopter-based Emergency Medical Services; PCCD: Pelvic Circumferential Compression Device; PPV: Positive Predictive Value; NPV: Negative Predictive Value.



Type A
Isolated fractures that do not disrupt pelvic ring
Stable

Type B
Anterior-Posterior or Lateral Compression
Rotationally Unstable
Vertically Stable

Type C
Vertical Sheer
Rotationally Unstable
Vertically Unstable

Figure 2. Pelvis fracture classification.

	Criteria	Points
Condition	Age ≥ 70 years	1
	High energy trauma	1
	Penetrating trauma/Open pelvic injury	1
	Shock-Index ≥1	1
Intervention	Cardiopulmonary Resuscitation (CPR)	1
	Substitution of >1 L fluid	1
	Intubation	1
Recompensation	Catecholamine necessary	1
	Remaining shock (≤90mmHg) under therapy	1
Score	**C + I + R**	=
Results	≤ 2 peripelvic vascular injury possible = 3-5 peripelvic vascular injury probable = 6-8 peripelvic vascular injury most likely = 9 peripelvic vascular injury is apparent	

*Adapted from Spering et al, 2024 (92).

Figure 3. Pelvic vascular injury score (P-VIS).

difference in hospital length of stay, ICU length of stay, or mortality (60). Similarly, Trentzsch et al., found no difference in mortality among propensity-score matched pairs when comparing PCCD use to nonuse (42). Ghaemmaghami et al., also found no difference in hospital mortality rate for patients with shock who received a PCCD in the emergency department vs historical controls who did not receive a PCCD (59). Similarly, Reiter et al.'s evaluation of 66 patients with unstable pelvic fractures and a mean ISS score of 21.9 found no difference in survival rate between patients without a PCCD, those with an ideally placed PCCD, or those with a PCCD placed outside the ideal anatomic position (23).

Risk of Harm/Complications

Evidence regarding complications of pelvic splinting is limited to three case studies and one case series, all describing in-hospital complications. Prolonged application of sheet wraps and pelvic splints can lead to skin breakdown, especially with prolonged application (134). Other reported complications include bladder incarceration in the pubic symphysis, muscle necrosis, vascular injuries resulting in worsening hemorrhage, and exacerbation of acetabular fractures and Morel-Lavalee lesions (111,119,141). Though these papers provide qualitative evidence of iatrogenic injuries from PCCDs, we were unable to find any studies that could quantify the risk for iatrogenic injuries or to identify any risk factors for iatrogenic injuries.

If PCCDs are used, care must be taken to ensure they are placed in anatomically appropriate position over the trochanters, and that the legs are internally rotated by securing the feet together.

Multiple studies have demonstrated frequent improper placement of PCCDs: up to 50% are malpositioned, with a too superior position being most common and misplacement more often occurring in female (63%) vs male (37%) patients (78,142,146,150). Emergency medical services clinician experience and trauma exposure may play a role in accuracy of PCCD placement. A prospective observational pilot of 26 paramedics in the United Kingdom (13 ground-based, 13 helicopter-based) assessed their accuracy of placing a PCCD on a simulated adult trauma patient. Despite nearly 100% accuracy in verbally reporting appropriate landmarks for PCCD placement, only 23% of ground

medics and 61.5% of helicopter-based medics were able to identify the correct landmarks, and only 39% of PCCDs were correctly placed (15.4% ground-based, 61.5% helicopter-based) (122). In addition to misplacement, other authors have raised the concern that PCCDs are placed without also splinting the lower extremities. Four papers emphasize that PCCDs should be centered over the greater trochanters and that the patient's legs should also be internally rotated by securing the feet together (44,79,110,120).

Splinting Methods and Devices

We reviewed four articles related to specific methods of pelvic splinting. No commercial device proved superior to the others in multiple studies, though commercial devices do appear better than improvised sheet-wrap PCCD techniques. A cadaveric study demonstrated similar pelvic reduction regardless of commercial device (117). A comparison study of the T-pod PCCD and a sheet-wrap technique performed on five cadavers demonstrated no difference in pelvic stability between the techniques (129). Another cadaveric study showed that commercial devices and sheets all reduced pelvic volume, but improvised sheets quickly failed to maintain tension (25). A retrospective review of 207 patients treated with pelvic splinting found that sheet wrapping was associated with a significantly higher incidence of lethal pelvic bleeding compared to the commercial PCCD device T-POD or an operating room-applied c-clamp stabilization (23% vs 4% vs 8%, respectively) (71). The World Society of Emergency Surgery recommends commercial pelvic splints over sheet wrapping in its 2017 guidelines (104).

Overall, the evidence supporting use of prehospital PCCDs to improve outcomes in patients with unstable pelvic fractures is weak, and risk of iatrogenic injury has potential to erode any benefit that may exist. If PCCDs are used in the prehospital setting, care must be taken to ensure that they are placed in the appropriate anatomic position and that the legs are also secured.

EMS clinicians should transport patients with suspected pelvis fractures who also meet other triage criteria of the National Trauma Triage Guidelines to a major trauma center, when possible. Transport via air-based EMS may be appropriate in select circumstances.

Twelve articles discussed triage and transport of potential pelvic fracture patients (Table 6). The 2021 National Trauma Triage Guidelines includes suspected pelvic fracture as a "red criteria" injury pattern indicating high risk for serious injury and recommends that patients with suspected pelvic fracture be directly transported to the highest-level trauma center available within the geographic constraints of the regional trauma system (154). Similarly, the French Society of Anesthesia & Intensive Care Medicine (SFAR) 2019 guideline recommends that patients with suspected pelvic fractures should be directly transported to a trauma center where surgical and interventional radiology services are available within 60 min of arrival (114). These guidelines are consistent with the evidence in our review, which demonstrate that pelvic fractures are commonly associated with other significant injuries.

However, due to the difficulty of identifying pelvic fractures in the field, it may be prudent to carefully consider whether pelvic fracture should be used in isolation as an indicator for trauma center need. Lerner et al., identified that the likelihood ratio (LR) of prediction of trauma center need based on EMS-identified pelvic fracture is only 1.9 (95% CI 1.3–2.9), compared to a LR of hospital-identified pelvic fracture of 6.2 (95% CI 4.9–7.9) (24). Transport of patients with suspected pelvic fractures to hospitals that are not major trauma centers might be acceptable for some patients. Rozenberg et al., found that despite having a higher severity of injury and risk of mortality, motor vehicle collision patients with pelvis or femur fractures that were transferred to a Level I trauma center did not have higher mortality than those who were directly transported to a trauma center from the scene (3). However, transport to a non-major trauma hospital may have negative repercussions in some patients, particularly for the elderly who have higher mortality related to pelvic fractures (35,65). Garwe reported that direct transport of geriatric (≥55 years old) patients with pelvic ring disruption to a Level 1 trauma center decreased complications in the first 2 weeks following injury (147).

Even if pelvis fractures are suspected, if the patient is hemodynamically stable and without a major mechanism of injury it may be reasonable to transport them to a closer non-trauma hospital for further evaluation instead of a more distant major trauma center. A retrospective study of trauma patients arriving at hospital with a pelvic binder in place (36.4% of whom had a pelvic fracture) showed that abnormal prehospital hemodynamics had a sensitivity of 80% and specificity of 32%, and a negative predictive value of 93% for identifying need for pelvic intervention within 24 h (51). When normal hemodynamics were combined with absence of a major mechanism of injury, these predictive measures achieved a sensitivity of 100%, specificity of 51%, and NPV of 100% for pelvic intervention within 24 h (51).

Decisions to use air medical transport should be based on other indicators of injury severity and potential patient benefit as described in national air medical use guidelines (155). Suspicion for pelvic fracture by itself should not drive decisions to transport patients by helicopter EMS vs ground EMS.

Pelvic splinting is a low-frequency skill that is not without risk to the patient. Agencies that include use of PCCDs in their protocols should ensure their EMS clinicians receive initial and ongoing training and education that addresses the development of both cognitive and psychomotor aptitudes related to pelvic fracture identification and management. The training should be comprehensive and directed by quality improvement programs. Pelvic fracture identification, proper patient selection, and appropriate placement and tension of pelvic splints should be emphasized.

Emergency medical services clinician education regarding pelvic fracture identification and management received brief mention in many papers, but no papers specifically focused on EMS clinician education. Provision of training appears to be highly variable, as evidenced by a survey of Level 1 trauma centers and paramedic agencies that found training

on pelvic splint placement typically occurs more at high-volume centers (77%) than low volume centers (25%) (76). Despite multiple papers and consensus statements emphasizing the importance of minimizing pelvic manipulation during physical exam and patient packaging, and providing guidance on careful patient selection, proper device placement, and other packaging techniques, deficiencies in EMS recognition of pelvic fractures and appropriate placement of PCCDs persist. These gaps might be mitigated through education and training, though there is no evidence that such efforts will translate to improved patient outcomes.

If EMS services wish to include use of PCCDs in their protocols they must ensure PCCDs are used appropriately and safely. This might be accomplished by providing education focusing on accurate identification of pelvic fractures, selection of patients for pelvic splinting, proper device placement, and concomitant appropriate positioning and splinting of the lower extremities.

Pelvic Fractures in Special Patient Populations

Education should also address the impact of pelvic fractures and use of PCCDs in specific populations. Our review included four papers that discuss pelvic fractures in elderly patients, five in pediatric patients, three in pregnant patients, and two in patients with significant obesity (Table 7).

Elderly patients with pelvic fractures are at particular risk, including higher odds of mortality, prehospital hypotension, and the need for massive transfusion (35,50,65,147). Age >60 years old is also noted to be a risk factor for missed pelvic injuries (81). Our review found no literature specific to application of PCCDs to elderly patients.

Pediatric patients with pelvic fractures represent 2% of trauma admissions in one US-based major trauma center study, occurring most commonly in pedestrians struck by motor vehicles or occupants of motor vehicle collisions (86). Most children with pelvic injuries sustain severe multisystem trauma, with fatal cases usually attributed to concomitant severe head injury (40). We identified only one paper that addressed use of PCCDs in pediatric patients. Reyes et al. found that both of the commercial PCCDs they evaluated fit "pediatric" patients that were taller than a length-based tape (>143cm), but only the Pediatric Pelvic Binder device fit patients less than 143 cm (12). However, the study did not perform an assessment of fit stratified by different sizes of pediatric patient, and it is unclear how well these devices fit younger pediatric patients.

Obese patients appear at higher risk for pelvic fractures and have a higher risk for mortality associated with these injuries (32,150). There are conflicting studies whether obesity impacts accurate anatomic placement of PCCDs (32,146,150).

Pregnant patients with pelvic fractures are at risk for placental abruption, and fetal mortality associated with maternal pelvic fractures and other trauma ranges from 30 to 65% (34,66,152). Much of this trauma occurs in unrestrained pregnant patients that are involved in motor vehicle collisions and may be impacted by a transient physiologic osteoporosis that can occur during pregnancy (152). If PCCDs are used on pregnant patients, care must be taken to ensure they do not impair placental perfusion by imparting excessive compression of the uterus. Additional discussion of trauma in pregnancy, pediatric patients, and geriatric patients is provided in companion papers to this manuscript in the NAEMSP prehospital trauma compendium (156,157).

EMS physicians play an important role in developing curricula and leading quality management programs to both ensure that EMS clinicians are properly trained in the recognition and management of pelvis fractures and that interventions for pelvis fractures are performed appropriately, safely, and effectively.

Our literature review found no papers that discussed EMS quality management practices specific to field management of pelvic fractures. Emergency medical services systems performing pelvic splinting should establish continuous quality management practices that use both qualitative and quantitative measures of performance to assess clinician competency in patient identification and PCCD placement and to maintain surveillance of clinical outcomes and iatrogenic injuries related to PCCD placement and other aspects of prehospital pelvic fracture management.

Considerations for Implementation

Implementation of the recommendations in this document may require revision of existing training paradigms and clinical protocols that emphasize the use of pelvic splinting in the prehospital setting. Purchase of new equipment to implement these recommendations is unlikely to be necessary. Although devices are relatively inexpensive, prehospital use of PCCDs does incur equipment and training costs. Opportunity costs are also present when limited equipment and training resources that could be used to support more impactful interventions are instead used to support use of PCCDs in the field.

The value of PCCDs in the prehospital management of unstable pelvic fractures is questionable and PCCDs are not without risk for iatrogenic injury. It appears reasonable for EMS agencies that currently use PCCDs to discontinue their use. If EMS agencies consider discontinuing use of PCCDs they should advise local trauma systems of this change, as education of clinicians at receiving trauma hospitals may be necessary to help them gain an understanding and acceptance of any changes in use of PCCDs in the prehospital environment.

For EMS agencies that choose to continue use of PCCDs, it may be necessary to dedicate more training resources to ensure EMS clinicians are appropriately educated on patient selection criteria and appropriate anatomic placement of PCCDs and splinting of the lower extremities. Agencies and systems should also dedicate quality management resources toward monitoring for proper use of PCCDs and assessing for positive and negative impacts on patient outcomes.

Limitations

Our literature review and development of recommendations was based on somewhat limited direct EMS-based evidence,

inconsistent reporting of outcome measures, and significant heterogeneity in clinician scope of practice across included papers. Multiple papers in our review were based on studies performed in European EMS systems, which may differ in clinician staffing and protocols compared to US-based EMS agencies. Further, our literature search strategy may have missed some articles germane to our discussion. Additionally, due to resource limitations we were unable to grade the evidence or perform a risk of bias assessment such as would be performed using GRADE methodology.

Conclusions

Although unstable pelvis fractures are associated with significant morbidity and mortality, extra-pelvic sources of bleeding are the most likely source of risk and EMS clinicians must remain vigilant for other causes of shock in these patients. The theoretical benefit of prehospital use of pelvic circumferential compression devices to reduce morbidity and mortality from pelvic hemorrhage has not been clearly demonstrated in clinical studies and these devices are commonly misapplied. Based on current data it is reasonable for EMS systems to consider discontinuing their use and agencies or systems that chose to continue their use must ensure adequate training and quality management resources such that PCCDs are applied correctly in the appropriate population.

External Review

This document was authored by NAEMSP and was not subject to review by any external organizations.

Updating Procedure

Pursuant to NAEMSP Standards & Clinical Practices Committee procedures and practices, this position statement and resource document will be reviewed and updated 5 years after its publication. Applicable NAEMSP review and revision practices that are current as of the time of the review will be followed. At a minimum the review process should include a search and synthesis of any new and relevant evidence that is published since the printing of this document.

Authors Contributions

JWL and NB developed the plan for literature review and evidence extraction. All authors assume full responsibility for the collection and integrity of the data. All authors except NB participated in the evidence extraction and data analysis. All authors participated in development of the clinical practice guideline. JWL and JGC wrote the initial draft of the manuscript, all authors participated in editing. All authors assume full responsibility for the entire content of the manuscript.

Declaration of Generative AI in Scientific Writing

The authors did not use a generative artificial intelligence (AI) tool or service to assist with preparation or editing of this work. The author(s) take full responsibility for the content of this publication.

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