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Introduction

In recent years there has been an increase in pelvic injuries due to an increase in road traffic collisions (RTCs) (Chesters 2017). Two thirds of pelvic injuries are due to RTCs and the remainder are made up of pedestrian collisions, motorcycle accidents and falls from heights. Patients with fatal pelvic injuries more than likely die of exsanguinations and/or associated severe injuries (ibid.). Lee & Porter (2007) undertook a literature review to analyse the current practice of assessing and managing pelvic injuries in pre-hospital situations. They write that the mortality rates of patients with pelvic fractures are estimated between 7% and 19%, upon their arrival at hospital. The mortality rates of patients with 'open book' fractures can be as high as 50%. An 'open book' fracture can be defined as any serious fracture that causes the pelvic ring to open like a book. This is commonly seen in anterior injuries to the pelvis widening the pubic symphysis (Gerecht, Larrimore & Steuerwald 2014). Lee and Porter (2007) argue that paramedics can help reduce the retroperitoneal space that a patient can haemorrhage into, and therefore lower the mortality rates for patients with 'open-book' pelvic fractures. Given the high mortality rates associated with pelvic injuries and the role paramedics can play in reducing these outcomes, the aim of this narrative review is to synthesize existing literature about pelvic injury recognition, assessment and management in pre-hospital situations. The authors will also conclude upon any new insights or recommendations found following the review.

Method

The authors undertook a narrative review systematically in order to meet the aim stated above. The inclusion criteria were UK and international peer-reviewed and published literature, academic papers and grey literature from the only two UK professional journals

(British Paramedic Journal and the Journal of Paramedic Practice) for paramedics as well as the 2016 UK Ambulance Services Clinical Practice Guidelines and the 2017 Clinical Practice Supplementary Guidelines. The search was from 2007 to 2017 with some exceptions for older seminal literature which was highly relevant to the topic. Additionally, articles not written in English and those not meeting the aims of the review were removed. Table 1 outlines the search terms used.

Fink (2014) argues that literature older than 10 years of age is no longer contemporary and should not routinely be used within an academic review, as it can diminish the credibility. The academic, peer-reviewed papers were identified using a selection of databases EBSCO; ProQuest; PubMed; Google/Google Scholar; Applied Social Sciences Index & Abstracts (ASSIA); British Nursing Index; Scopia; British Library: Medicine ebook collection; AMED; Health and Psychological Instruments and HMIC. In the initial search phase, duplications were removed, article titles and abstracts from all databases were read for relevance before a more rigorous assessment. In the next phase the bibliographies and reference lists of the chosen articles were carefully scanned in order to find relevant articles not found in database searches. Using this approach, in total 84 articles were identified as potentially relevant. Once the articles were read fully, 20 UK and international peer-reviewed and published articles and grey literature pieces were included in the narrative review.

Additionally, a table of the 20 articles that were deemed relevant for this review was generated (Table 2) along with a PRISMA diagram (Diagram 1).

Findings

Two overarching themes were identified. The first related to issues with defining and measuring mortality rates associated with pelvic injuries. The second theme of assessment

and management comprised of the following four subthemes: UK Ambulance Service Guidance; Log roll and 'springing'; The use of pelvic binders/splints; and Triage.

Mortality Rates

A study published by Dong & Zhou (2011) looked at the management and outcomes of open book pelvic fractures. The researchers considered 41 patients who had suffered open book fractures and other, non-stated, traumatic injuries. They measured patients' Injury Severity Score (ISS) and stated that the higher the ISS, the greater the amount and severity of trauma the patient had suffered. The average ISS was found to be high suggesting most studied patients suffered poly trauma. Mortality rates remain high despite advances in the assessment and management of pelvic injuries in recent years, this is most likely due to the poly trauma that has occurred to these patients, making the estimation of open book fractures and the chance of mortality they engender unreliable. To understand the true mortality rates from pelvic injuries, only patients with isolated pelvic injuries should be reviewed. However, Dong & Zhou's (2011) research did not consider pre-hospital management of the patients as an affecting factor.

Giannoudis et al. (2007) compared trauma patients with pelvic ring fractures to patients without pelvic injury to determine factors predicting mortality (years 1989–2001). Their study had prospective data from 106 receiving trauma hospitals in England and Wales (Trauma Audit and Research Network (TARN)). In total 11 149 out of 159 746 patients had pelvic ring fractures whereas 133 486 did not. This study confirmed that patients with pelvic injuries had higher Injury Severity Scores (ISS > 15 32.1% compared to 14.4% with patients without pelvic injury) indicating that pelvic injuries are more often associated with other injuries. Giannoudis et al. concluded that early transfer of patients with several injuries,

including pelvic injuries, should be considered to improve survival rates. Similarly, Williams-Johnson's (2010) found that improvements in outcomes for patients with pelvic injuries in the US can be attributed to advances in pre-hospital and hospital emergency care, interventional radiology, surgical and critical care. Equally, Papadopoulos et al. (2006) performed an autopsy based retrospective study on 655 patients with a pelvic fracture. Their study highlighted that although pelvic injuries were not the only cause of mortality, they were a substantial contributing factor.

Studying the management of pelvic fracture among 6 – 16 year old children, Banerjee et al. (2009) retrospectively analysed patients admitted in a Level 1 Trauma Centre in London in a 10 year period. All patients evacuated by the Helicopter Emergency Medical Service (HEMS) were entered into a comprehensive trauma database. In total 44 patients with pelvic fractures were submitted by HEMS in the 10 years studied, of which 7 patients died. The most common mechanism of injury was a pedestrian hit by car, and a stable type of pelvic injury was the most predominant injury. Long bone fracture and head injury were the most common associated injuries. ISS, Revised Trauma Score (RTS) and Glasgow Coma Scale (GCS) were significantly ($p < 0.05$) altered in the non-survivors compared to survivors. Banerjee et al (2009) concluded that although pelvic fractures in children may have a good long term outcome, pelvic injuries are a potential indicator of other serious bodily injuries which carry a high mortality risk.

Balogh et al. (2007) in Australia concluded that bleeding is the primary cause of pre-hospital related mortality in all measured pelvic fracture groups. Gabbe's (2011) highlights the importance of effective control of haemodynamic instability for reducing the risk of mortality. In addition, Cordts Filho Rde et al. (2011) conducted a retrospective analysis of

protocols and records of victims of blunt trauma in a six month period over 2008-2009. The patients were separated into two groups: Group 1: with pelvic fracture and Group 2: without pelvic fracture. The study was set to assess whether the presence of a pelvic fracture was associated with greater severity and worse prognosis in victims of blunt trauma. The findings showed that Group 1 had significantly lower average blood pressure, higher mean heart rate, lower mean GCS, the highest average Abbreviated Injury Scale (AIS) in the segments head, chest, abdomen and extremities, as well as a higher mean ISS and lower mean TRISS and RTS on admission. Therefore, it was concluded that the presence of pelvic fracture is a marker of greater severity and worse prognosis in victims of blunt trauma.

Considering all of the above studies it can be argued that there is a clear need for rapid and effective pelvic injury assessment and management to help lower mortality rates. This can be considered to be even more crucial in the pre-hospital environment as the sooner these fractures are recognised and stabilised the better the potential outcome will be.

Furthermore, clinician's should have a high index of suspicion of patients with pelvic injuries and a high ISS score, which will increase the likelihood of mortality. Further research is required on what prehospital factors are associated with increases or reductions in mortality rates where there is poly-trauma.

Assessment and Management

UK Ambulance Service Guidance

According to the 2016 UK Ambulance Services Clinical Practice Guidelines, pre-hospital management of suspected pelvic fracture should adhere to the following principles. Any patient found to have a mechanism of injury associated with a pelvic injury and a concomitant hypotension must be managed as having a time critical pelvic injury. These patients should be rapidly transferred to the nearest suitable hospital. The pelvis should be assessed for bruising, bleeding, deformity, swelling and potential shortening of a lower limb. It is stated that 'springing' of the pelvis should not be carried out. High flow oxygen should be administered until vital signs have returned to normal. Additionally, an appropriate splint should be applied directly to skin, preferably before moving the patient. The circumferential pressure from the splint should be directly over the greater trochanters. Log rolling the patient should be avoided and a scoop stretcher should be used to extricate the patient where possible. The patient's pain should be managed appropriately using Entonox or Morphine (AACE, 2016).

In addition to this the 2017 UK Ambulance Services Supplementary Guidelines state that Tranexamic Acid should be administered as soon as possible with active or suspected active bleeding. An improvised splint (binder) can be used if the purpose made splint does not fit. The pelvic injury should not be reduced beyond its anatomical position. This process should occur on scene as soon as possible and at most a 10 degrees tilt should be utilised while managing these patients. Finally, clinician's should use intravenous paracetamol as a first line analgesic and Morphine if further pain relief is required (AACE, 2017).

Log roll and 'springing'

To outline the emerging best practice when packaging pre-hospital trauma patients while providing spinal immobilisation, Moss et al. (2013) reported the recommendations of a consensus meeting held by the Faculty of Pre-Hospital Care, Royal College of Surgeons of Edinburgh in April 2012, where experienced clinicians from pre-hospital and emergency care deliberated the evidence. Increasing evidence suggests that movement and changes in patient position and orientation contributes to internal haemorrhage: e.g. exacerbated a fractured pelvic ring when log rolling the patient. Also, the patient should be immobilised 'scoop to skin' and a pelvic splint should be applied. The recommendation states minimal handling and one movement, therefore the consensus no longer supports the routine use of the spinal board for spinal immobilisation; a Scoop Stretcher should be used instead. Lee & Porter (2007) & Moss et al (2013) agree, proposing that patients with pelvic injuries should not be log rolled due to the risk of aggravating the injury and dislodging any clots. This will lead to further haemorrhage, a higher risk of mortality and additional discomfort to the patient.

'Springing' the pelvis to assess for pain or deformity was suggested in the American College of Surgeons advanced trauma textbooks (NAEMT, 2004), this method is unreliable and leads to clots being dislodged and the exacerbation of any injuries (AACE, 2016; AACE, 2017). Additionally, Lee & Porter (2007) found that springing the pelvis showed a specificity of 71% and a sensitivity of 59%. Paramedics should use the mechanism of injury, history taking, inspection of the pelvis and vital signs as their main assessment tools.

Pelvic binders/splints

A study by Krieg et al. (2005) concluded that a pelvic circumferential compression device effectively reduces pelvic ring injuries, and cannot over compress the fracture, which leads to increased mortality. Case studies such as Fleiter et al. (2012) support this. A paramedic could use this device if available to keep complications minimal. On the other hand, this study only used 16 patients so the results should be used with caution.

The Faculty of Pre-Hospital Care (FPHC) recommended in 2013 stated that a pelvic binder should be applied if any one of the following four risk factors is present in any setting where the mechanism of injury suggests a possible pelvic injury. Any patient with a heart rate greater than 100 beats per minute, a systolic blood pressure of <90mm Hg, a Glasgow Coma Score of 13 or less and a distracting injury and/or pain on pelvic assessment (FPHC, 2013).

To examine the evidence associated with pelvic binding devices and their application Scott et al. (2013) conducted a literature review including the findings of a consensus meeting on the pre-hospital management of pelvic injuries held in 2012. They concluded that there is no evidence in the literature to help guide a recommendation whether a pelvic binder should be applied prior to extrication or not. They write that it is logical that placement happens prior to extrication where possible as the movement of an unstable fracture can disrupt clot formation. However, this area needs further investigation to find the optimal method for placement of a binder.

An examination of missed injuries in a physician-led pre-hospital trauma service found that pelvic fractures were often missed. Yong et al. (2016) assessed the Faculty of Pre-Hospital Care's 2013 guidelines and found that of all the 170 blunt trauma patients, 26 (15.3%),

sustained pelvic girdle injury and 45 (26.55%) had a pelvic binder applied, and 8 (31%) fractures were missed. Even with a detailed clinical assessment and low threshold for splint application, this study illustrates the problems of distracting injury when trying to diagnose and manage pelvic fractures. The authors found that the Faculty of Pre-hospital Care's Pelvic Injury Guidelines could have reduced missed injuries from 31% to 8%.

Triage

Helm et al. (2013) carried out a retrospective analysis and comparison of pre-hospital and in-hospital trauma records of road traffic accident victims treated by HEMS and transferred to a level 1 trauma centre (479 patients). They compared pre-hospital and in-hospital diagnostic findings according to the Abbreviated Injury Scale (AIS) to determine the accuracy of pre-hospital emergency physician field triage in road traffic accident victims. Their results showed that a correct pre-hospital field triage of patients (by emergency physicians) with an AIS \geq 3 of the head 77%, chest 69%, abdomen 51%, pelvis 49%, extremities 70%, neck/cervical spine 67% and thoracic/lumbar spine 70% was achieved. Helm et al. conclude that accurate field triage in seriously injured road accident victims, even by trained physicians, is difficult. This pertains especially to injuries to the abdomen and pelvis. It is further recommended that for the field triage a combination of anatomical and physiological criteria as well as the mechanism of injury should be used to increase accuracy. As pelvic injuries often represent significant trauma, and have other serious associated injuries, these patients should automatically be taken to Major Trauma Centres because of their well-rehearsed trauma protocols and facilities for appropriate emergency interventions, critical care and rehabilitation (Chesters 2017) The authors of this review

speculate that if pre-hospital triage is difficult for experienced HEMS physicians, then paramedics will also find it difficult.

Kirves et al. (2010) retrospectively analysed 422 adult trauma patients seen by a trauma team, to gauge whether the training and qualifications of the clinicians present were associated with the accuracy of prediction of anatomic injury, and implementation of local pre-hospital guidelines. To evaluate accuracy of prediction of anatomic injury, clinically assessed pre-hospital injuries in six body regions were compared to injuries assessed at hospital in two patient groups: patients treated by pre-hospital physicians (group 1, n = 230) and patients treated by paramedics (group 2, n = 190). Kirves et al. found that the consistency of pre-hospital assessed injury with in-hospital assessed injury was poor in abdominal, pelvic and spinal injuries. Similarly, a study by Lustenberger et al. (2016) in Germany found that a significant proportion of severe pelvic fractures were not suspected by the emergency physician at a scene. Available research data indicates that only a combination of clinical findings can safely rule out pelvic fractures, but these findings cannot often be captured by a short physical examination at the scene of the accident or during transport (ibid). This therefore highlights the importance of an early, pre-hospital mechanical stabilization of the pelvis for severely injured patients, irrespective of the results of the physical examination (ibid.). On the other hand, Lustenberger et al. (2016) concluded in their retrospective study of patients with a missed pelvic injury in the pre-hospital setting, that a missed pelvic injury did not significantly impact the in-hospital outcome with regards to mortality and the requirement for an early transfusion. They argue that there needs to be specifically designed prospective studies in order to evaluate the impact of “missing a pelvic injury in the pre-hospital setting” on different in-hospital outcome variables (ibid.).

Conclusion

The literature confirms that the presence of a pelvic fracture is a marker of greater severity and worse prognosis in victims of blunt trauma. It also highlights that mortality rates remain high despite advances in the assessment and management of pelvic injuries in the recent years. The high rate of mortality of patients with pelvic injuries is most likely due to poly trauma, as pelvic injuries are more often associated with other serious bodily injuries.

Studies in the UK and abroad show that for patients with pelvic injuries, bleeding is the primary cause of pre-hospital mortality, and Injury Severity Score (ISS), not the type of injury, is the best predictor when determining these patient's mortality. International research also confirms that advances in pre-hospital and in-hospital emergency care improve the outcomes for patients with pelvic injuries. Further research is required on what prehospital factors are associated with increases or reductions in mortality rates where there is poly-trauma. Additionally, research is needed to identify the impact of missed pelvic fractures in the pre-hospital environment.

Distracting injuries are a potential concern when diagnosing and managing pelvic injuries. Accurate pre-hospital triage of patients with serious injuries to the abdomen and pelvis, even by trained physicians, is difficult. Pelvic injuries are often not the only cause of mortality with these patients. International research confirms that pre-hospital assessment of blunt trauma is difficult and more dependent on the skills of the personnel, and that the consistency of pre-hospital assessed injury with the in-hospital assessed injury is especially poor in abdominal, pelvic and spinal injuries. The authors of this review speculate that if pre-hospital triage is difficult for experienced physicians, then UK paramedics will also find it difficult.

To improve survival rates for patients with pelvic injuries, there is a need for rapid and effective pre-hospital pelvic injury assessment and management, as well as an early transfer to hospital, preferably to a Major Trauma Centre. Guidelines on how to assess and manage patients with pelvic injuries recommend minimal handling, scoop stretchers instead of long spinal boards, and removal of clothing when placing pelvic splints/binders on patients. All literature and guidelines speak against log-rolling the patient and springing the pelvis when there is a suspicion of pelvic injury, instead mechanism of injury, history, inspection and vital signs should be used as the main assessment tools. Furthermore, there is no evidence currently to suggest whether the application of a pelvic binder/splint prior to extricating patients from an RTC will improve outcomes or not. However, the authors of this review speculate that the earlier an unstable pelvic fracture is stabilised the better the outcome will be for that patient. Further research is needed in this area.

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