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Editorial

The use of pelvic binders in the emergent management of potential pelvic trauma

The prevalence of pelvic fracture in patients with blunt trauma is between 5% and 16%.[1–4] A significant proportion of deaths from pelvic fracture are due to exsanguination and patients who are haemodynamically unstable on arrival to the Emergency Department have a much higher mortality rate than the stable patient.[5] The sooner bleeding is controlled, the greater the chance of avoiding "the lethal triad" of hypothermia, coagulopathy and acidosis secondary to hypotension and hypoperfusion of tissues.[6,7] In recent years, pelvic circumferential compression devices (PCCDs), or "pelvic binders", have become widely adopted as part of resuscitation protocols worldwide and are now in established use by many trauma care providers.[8–11] The pelvic binder has been promoted to maintain or restore mechanical stability to the pelvis and haemodynamic stability to the patient with a suspected pelvic ring injury prior to operative intervention or angiography.[12,13] The reduction and stabilisation of the pelvic ring is believed to decrease fracture site bleeding[14–16] while protecting any initial blood clot from disruption. In theory, a decrease in the pelvic volume[17] may create a tamponade thus reducing venous bleeding.[18–20] What is the clinical evidence to support the use of a pelvic binder and what are the problems, if any, with it's use? Are all pelvic fracture types suitable for treatment with a pelvic binder and how long can the binder safely be maintained?

Pelvic compression has long been advocated as a means of controlling haemorrhage in patients after pelvic injury. Early improvisations for pelvic wrapping used bed sheets, belts or slings. In the mid-1970s Medical Anti Shock Trousers (MAST)[21,22] and G-suits[22] were introduced but these proved cumbersome to use and restricted access to the abdomen and lower limbs. The alternative method of emergency treatment using pelvic external fixation devices [23,24] was advocated but required surgical intervention. However, modern commercial devices allow for improved exposure of the casualty and include the "*Pelvic Binder*" (Pelvic Binder Inc., Dallas, Texas, USA), "*Trauma Pelvic Orthotic Device*" (TPOD) (Cybertech Medical TM, California, USA), "*SAM-sling*" and "*SAM Pelvic Sling II*" (SAM Medical Products TM, Oregon, USA), the "*Stuart Pelvic Harness*" (Medistox Ltd., Blackburn, UK) and the *Pelvigrip* (Ysterplaat Medical Supplies, South Africa).

The application of a pelvic binder has become part of the emergency care of all trauma patients who may have sustained a pelvic fracture, in both the pre-hospital environment, and in the emergency department. Modern binders are light, easily portable and simple to apply. Many Western paramedical services and military units now carry them for application at the scene of injury. Whilst their introduction has not been unduly contested, what is the evidence for their efficacy?

There are three biomechanical studies on cadaveric specimens that provide evidence of effective pelvic reduction with binders in "open book" or Anterior Posterior Compression injuries (Young and Burgess classification).[15,25–28] Researchers found that a pelvis strap (the Sam Sling prototype) reduced the unstable open-book fracture when applied around the greater trochanters and the symphysis pubis and tensioned to 180 N.[27,28] They also tested rotational stability in terms of internal/external rotation and flexion/extension of the unstable hemi-pelvis in response to a 9 N m^2 stress with a binder in situ. The sling provided significant internal/external rotational stability, and non-significant but improved flexion/extension stability (on a par with a C-clamp, but less stable than anterior external fixation). The TPOD has been show to be effective in reducing the pubic symphysis in APC type II cadaveric fractures.[15]

In terms of clinical trials, a small prospective study ($n = 13$) suggested that a binder tensioned to 140 N was able to significantly reduce externally rotated pelvic fractures in an emergency setting[29,30] with an absence of complications and anecdotal evidence of pain relief in several alert patients. It can be shown that in vivo reduction of the pelvis is most effective when binding occurs at the level of the greater trochanters.[11,31,32] In a case series of 15 patients a statistically significant reduction of the symphyseal diastasis using the TPOD was reported.[33] This was similar to another study in 17 patients with the SAM Pelvic Sling II.[32] In the only pre-hospital study, there was anecdotal ease of use and good reduction in 19 patients using a pelvic strap belt (Geneva belt).[34] Case reports exist of almost complete reduction of the pelvic ring on computed tomography using an external compression splint (Stuart pelvic harness)[35] and the Sam Sling on X-ray.[36]

Early commercial compression devices (Medical Anti Shock Trousers [MAST][21] and G-suits[22]) produced no survival benefit,[37–39] but outcome indicators using later devices have been rarely measured. One study compared stabilisation with a pelvic binder (TPOD) to emergent pelvic external fixation in 186 patients and found a significantly reduced transfusion requirement in the TPOD group (at 24 h, 4.9 versus 17.1 units ($p < .0001$) and at 48 h, 6.0 versus 18.6 units ($p < 0.0001$)). Length of hospital stay (16.5 versus 24.4 days, $p = 0.03$) and mortality (POD 26% versus EPF (37%, $p = 0.11$)) was reduced in the binder group although this did not reach statistical significance.[4] The findings may have been subject to significant chronological bias in this study. Another study of seven patients showed improvement in haemodynamic status 15 min after pelvic compression with sheeting, but did not account for any concomitant resuscitative procedures.[40] There is no data on

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the effect of movement and transfer of the patient on the stabilisation effect of the binding device.

Are there downsides to using pelvic binders? Older compression devices (antishock garments) have been associated with abdominal compartment syndrome and pressure sores whilst also restricting access to the abdomen and lower extremities.[11,41–43] Modern binder devices allow more complete assessment of the abdomen, and permit laparotomy whilst in situ but do still restrict complete assessment of the perineum. Tissue damage, sufficient to cause pressure sores and skin necrosis, is believed to occur when contact pressures above 9.3 kPa are sustained continuously for more than 2 or 3 h.[44] Pressure at the binder/skin interface from a pelvic binder was found to exceed this threshold at the anterior superior iliac spine (ASIS), greater trochanters (GT) and sacrum in a study on 10 healthy individuals.[45] In a comparison of pelvic binder, SAM-sling and TPOD in 80 healthy volunteers, the pressures exceeded 9.3 kPa at the GTs in all devices whilst used on a spinal board. On a hospital bed, only the pelvic binder exceeded this theoretical tissue-damaging threshold.[46] The polytrauma patient is likely to be at increased risk of soft-tissue damage due to systemic factors promoting tissue breakdown[47] and trauma-associated local soft-tissue injuries.[48,49] These concerns are borne out by clinical reports of skin breakdown at the level of the bony prominences (symphysis and bilaterally around both the GTs) following folded sheet binding[43] and skin necrosis over the area of binder application (SAM sling prototype) for a patient with an unstable pelvic ring injury and associated closed internal degloving injury.[29] There is a report of devastating myelonecrosis following prolonged use of an improvised binder.[50] It remains uncertain how long a pelvic binder can be safely maintained and how often it should be released periodically to relieve and inspect the soft-tissues. One should follow the manufacture's instructions, if available, but our current recommendation is to discontinue use of the binder as soon as possible for definitive fixation of the pelvis or to release the binder briefly every 24 h if being maintained for longer.

There have been concerns that a pelvic binder may produce secondary displacement of a lateral compression (LC) fracture causing further damage. A small increase in internal rotation and reduction of pelvic inlet area in unstable LC type II fracture has been reported with the application of a binder in cadaveric studies.[27] In five patients with "partially stable" lateral compression fractures, there was a small over-reduction but this was not thought to be clinically significant.[30] There have been no studies involving binder use in unstable lateral compression fractures (LC type III) and there remains the possibility of damage to neurovascular structures and viscera with further internal rotation from binding. However, the degree of displacement of the pelvic ring is likely to be far greater at the time of injury than afterwards with the application of a binder. As yet, there are no case reports in the literature of binder application causing this potential damage in lateral compression injuries. The only commercially available device that allows for controlled tension to 147 N is the SAM Pelvic Sling II by use of an autostop buckle. Potential exists for damaging over-reduction in non-pressure limited or improvised devices. Application error has been recognised, mostly in placing a sling too high.[32,36] Binders applied in this position are known to require larger pressures to successfully reduce the pelvis in cadavers and will constrict the abdomen.[28] In a correctly placed binder, missed diagnoses of pelvic instability on primary survey radiograph can occur due the complete radiographic reduction of some APC fractures by binding.[34,35] To date there are no reports of loss of haemodynamic stability after binder removal.

In summary, pelvic binding is becomingly increasingly commonplace and new devices allow control over pressure delivery and improve patient exposure. There is sparse evidence on the biomechanical efficacy of modern binding, although the reports from cadaveric studies and case series suggest it helps in the reduction of unstable pelvic fractures and clot stabilisation. There has been little study of clinical outcome measures, although there are some data to support improved haemodynamic status with binder use in the immediate resuscitative phase. There is no clear consensus as to which of the commercially available binders is preferred although the SAM Pelvic Binder II and the TPOD are the most extensively described.

A very small number of complications have been documented, mainly involving tissue damage over the bony pressure areas in prolonged use. It is not clear whether application of a binder to unstable lateral compression fractures should be contraindicated but there have been no reports in the literature of complications from over-reduction. Vertical shear fractures have never been addressed in relation to binding – again it may help clot stabilisation in the initial resuscitation period. There is no evidence to suggest that temporary application will cause a deleterious effect in those who sustain either proximal femoral or acetabular fractures.

It is unlikely that a randomised controlled trial of the use of a pelvic binder will be possible and therefore strong evidence will always be lacking. Further outcome parameters should continue to be studied. In the meantime, application of a pelvic binder should be regarded as an adjunct to the immediate resuscitation of the hypovolaemic trauma patient. It is important to place it correctly over the greater trochanters. Its benefits are likely to outweigh its risks, particularly when used pre-hospital or in units that lack the surgical capability to rapidly stabilise the pelvis.[51] A binder is likely to buy time but users must be aware of the problems associated with prolonged use. Regular release, check of pressure areas and re-tensioning or prompt exchange to either external or definitive internal fixation is advocated. Further experience and clinical reports would help define its role in lateral compression and vertical shear fractures, and also when there are associated proximal femoral or acetabular injuries. Finally, a secondary survey cannot be deemed to be complete until a binder has been removed, the perineum examined and, if there is a clinical suspicion of a pelvic fracture, a further pelvic radiograph obtained out of the binder.

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