Original Article

TRAUMA

Trauma
0(0) 1–6

DOI: 10.1177/1460408614568831
tra.sagepub.com

SAGE

A bed sheet is not as effective as a pelvic circumferential compression device in generating pelvic compression in patients with a suspected pelvic fracture

Shrestha Sinha[1], Helen Ellicott[1], Ed Gee[2] and Alistair Steel[1]

Abstract

Introduction: The Advanced Trauma Life Support protocol for emergent management of pelvic ring disruptions includes advising circumferential application of a bed sheet. A number of purpose-designed pelvic circumferential compression devices are commercially available. We assessed whether the Advanced Trauma Life Support-recommended simple bed sheet was able to generate the same pelvic pressure as provided by a pelvic circumferential compression device.

Methods: A healthy volunteer was laid supine on an examination trolley and a pressure transducer was placed overlying the volunteer's greater trochanters. Two pelvic compression devices, a commercially available SAM Pelvic Sling II™ and a standard hospital bed sheet, were applied single handedly. The SAM Sling was applied according to the manufacturer's instructions and the bed sheet was applied in the way the participant felt best. The pressures generated at the level of the greater trochanters were measured at 2 min. The mean of the left and right pressures was recorded. Following removal of the first device, the second device was then placed and the pressures were again recorded at 2 min.

Results: Twelve participants completed the study. The mean (standard deviation) pressure generated by the SAM sling was 107 (28.4) mmHg and by the bed sheet 54 (26.3) mmHg; the SAM sling generated significantly greater pressure ($p < 0.0001$). A variety of different methods for applying the bed sheet were observed.

Conclusion: In patients with a suspected pelvic fracture, a bed sheet is unable to reliably generate pressures approaching those of a commercially available pelvic circumferential compression device.

Keywords

Trauma, pelvis fracture, compression device, bed sheet

Introduction

Major trauma is the most common cause of death in people under the age of 40 in the UK and worldwide.[1] Trauma patients with an unstable pelvic injury have mortality rates as high as 50%,[2–6] with haemorrhage being the major cause of death for patients with an unstable pelvic injury.[7–11] The main sources of bleeding from pelvic injuries are from fractured bony surfaces and from injury to the presacral venous plexus caused by shear forces at the time of maximum distraction.[12,13]

Pelvic binders, or pelvic circumferential compression devices (PCCDs), are recommended for use as a temporary form of stabilisation for pelvic injuries by the American College of Surgeon's Advanced Trauma Life Support program (ATLS).[14] Circumferential compression approximates and stabilises fracture ends to slow bleeding and reduces the potential volume of the pelvic basin.[2,5] Volume reduction increases the intrapelvic pressure causing a tamponade effect on venous haemorrhage. Stabilisation reduces the risk of further injury from a mobile hemi-pelvis, aids in clot formation, clot protection and contributes to pain relief.[15] Increasing stability prevents movements that can cause further injury to surrounding soft tissues such as blood

[1]Anaesthetic Department, Queen Elizabeth Hospital NHS Foundation Trust, King's Lynn, UK
[2]Orthopaedic Department, Manchester Royal Infirmary, Manchester, UK

Corresponding author:
Alistair Steel, Anaesthetic Department, Queen Elizabeth Hospital NHS Foundation Trust, Gayton Road, King's Lynn PE30 4ET, UK.
Email: alistair.steel@nhs.net

vessels. Biomechanical studies also show that PCCDs are a safe and effective method of temporary stabilisation of pelvic injuries.[16,17]

ATLS guidelines are the accepted and taught basic standard of trauma care around the world.[18,19] The ATLS protocol for emergent management of pelvic ring disruptions includes advising circumferential application of a bed sheet.[14] A number of commercial PCCDs are readily available. We assessed whether the ATLS-recommended simple bed sheet was able to generate the same pelvic pressure as provided by a standard commercial PCCD.

Methods

Prior to commencing the study, institutional approval was gained. The Research Governance Committee deemed that formal ethical approval was not required.

One male member of the study team was used repeatedly as a 'volunteer patient' in an attempt to standardise the anatomical landmarks and body mass distribution. Members of the hospital trauma team were asked to participate in applying the pelvic devices. They were enrolled during three data collection sessions spread over the course of two weeks. The trial ended when the requisite number of participants had completed the study.

Participants were selected from a single centre that experiences approximately 150 major trauma calls per year. Participants included within the study had to be recognised members of the trauma team, with a reasonable expectation that they could be asked in a trauma scenario to apply a pelvic compression device. Participants were excluded if they we unable to offer the time necessary to conduct the study. An information leaflet was given to participants explaining the reason for the study and reminding them of the appropriate landmarks for application of a pelvic compression device.

Hundred millilitre bags of saline were strapped overlying each of the greater trochanters of a live volunteer 'patient'. The same volunteer was used throughout the study to provide consistency of body habitus. A short rigid vascular catheter was inserted into each saline bag and connected via continuous columns of fluid to a standard clinical transducer set. The pressures within the bags of saline were measured using a DASH 3000 multimodality monitor.

Two pelvic compression devices were used: a commercially available SAM Pelvic Sling II^{TM} and a standard hospital bed sheet. The 'patient', a member of the study group, lay supine on an examination trolley with legs in the anatomical position. When the first device had been applied, the pressure generated was recorded at 2 min to allow a steady state to be achieved. The mean of the left and right pressures was recorded. Following removal of the first device, the second device was then placed and the pressures were again recorded at 2 min. Participants applied the devices on their own.

To reduce the risk of bias, either via a possible 'learning effect', direct feedback or fatigue, both participants and 'patient' were blinded to the measured pressures. Participants were also blinded to the bed sheet tying techniques employed by other participants. Allocation to using either the PCCD or bed sheet first was decided using simple randomisation (with an allocation ratio of 1:1).

Sample size for the study was calculated following a pilot investigation that showed a 50% reduction in pressure generated by the bed sheet and predicted standard deviation of 5 mmHg, giving a power of 0.8 and a type I error rate of 0.05 with a Cohens d of 2. Statistical significance was calculated using a paired t-test.

The primary outcome measure was the pressure generated over the greater trochanters by a compression device. No changes were made to the trial methodology or outcomes after the trial had commenced.

Results

Twelve participants from a range of specialties and of varying clinical experience completed the study. The participants comprised of anaesthetists, orthopaedic surgeons and emergency physicians, registrars and consultants. The mean (standard deviation) pressure generated by the SAM sling was 107 (28.4) mmHg and by the bed sheet 54 (26.3) mmHg; the SAM sling generated significantly greater pressure ($p < 0.0001$). The mean pressures and standard deviation generated by each device are given in Figure 1.

There was no harm or other unexpected outcome caused by either intervention. A variety of different methods for applying the bed sheet were observed (Figure 2).

Discussion

Temporary pelvic compression devices function by applying force over the greater trochanters, forcing the femur into the acetabulum and in turn reducing potentially distracted fractures of the pelvic ring. In addition to being easy to store and carry they are non-invasive, quick to apply, require minimal training and need little movement of the patient. Within the UK, the use of commercial PCCDs is considered within most systems to be the standard of care. For these reasons, it is a good practice to apply temporary pelvic compression in any patient with a suspected pelvic injury even

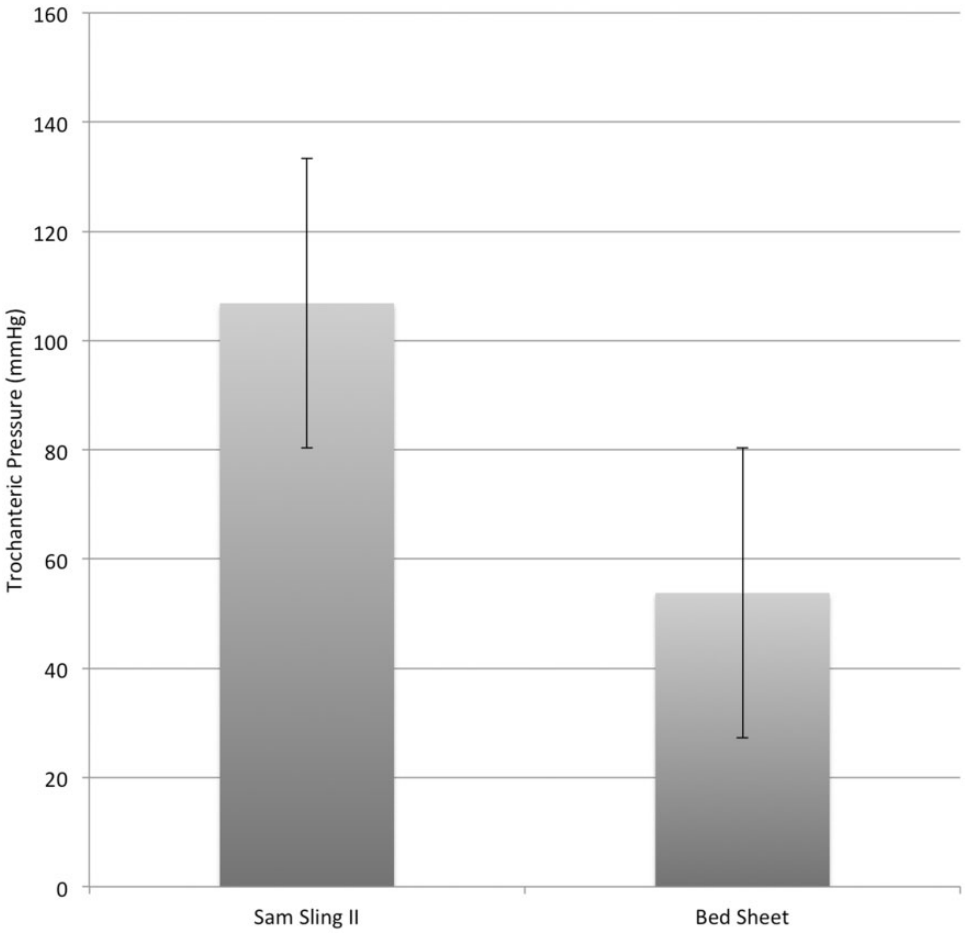

Figure 1. Mean and standard deviation of trochanteric pressures measured 2 min after device application.

before a definitive diagnosis of pelvic instability is made.

The evidence behind the use of a bed sheet as a temporary compression device is limited. However, their use is still advised in the ATLS guidelines that are followed worldwide in trauma care. The pressure characteristics of a circumferential sheet have not been evaluated previously nor compared to commercially available PCCDs.

Anecdotal reports of the use of a bed sheet as an external compression device in pelvic injuries are numerous, however little formal research is available on the subject. A few case reports exist supporting both clinical and anatomical improvement of pelvic fractures.

One case series, reporting two cases, describes a 'near-anatomic' reduction of pubic symphysis and left sacroiliac joint diastasis on plain film radiographs with the application of a circumferential pelvic bed sheet in one case.[15] The investigators attempted to quantify reduction of pelvic volume and diastasis using postintervention computed tomography images in conjunction with preintervention plain film radiographs and three-dimensional reconstructions. Anatomical landmarks were used on radiograph to predict prereduction position of bony parts and reconstruction software predicted diastasis and inlet area; 87% reduction of diastasis and 29% reduction of pelvic inlet area were estimated for one case and 38% diastasis reduction and 9% inlet area reduction were estimated in another.

Clinical improvements have been noted as well. Routt et al. encircled the pelvic region of one haemodynamically unstable patient with bilateral pubic rami fractures and sacroiliac joint disruptions in a snugly clamped sheet and noted improvement in blood pressure and heart rate.[11] Another report noted the application of a bed sheet-aided haemorrhage control, however, as the patient also had a femoral shaft fracture that was tractioned at the same time, this gives only anecdotal evidence.[20]

PCCDs, in contrast, have been studied in greater detail. They have been shown to improve rotational stability and flexion–extension stability when applied at the level of the greater trochanters and pubic symphysis in cadaveric biomechanical studies.[16] Increasing stability prevents movements that can cause further

Figure 2. Examples of the different techniques used to apply the bed sheet for pelvic compression.

injury to surrounding soft tissues such as blood vessels. The application of circumferential compression with a force of 180 N (approximately that generated by the SAM sling) was shown to completely close a pubic symphysis diastasis in anteroposterior compression fractures, the most common type of pelvic fractures.[21]

A device such as the SAM Sling allows pressure to be applied in a controlled and uniform fashion, having an auto-stop buckle to limit strap tension to 150 N. In contrast, the force applied by a bed sheet is uncontrolled and unrestricted during its application. Though no harm was caused by the application of the bed sheet, given that the 'patient' used did not have any pelvic disruption, we cannot extrapolate this finding to the clinical setting.

Reduction in pelvic volume would be a good measure when considering external compression devices. However, reduction in pelvic volume requires external pressure and it is known that commercial PCCDs apply sufficient pressure to effectively reduce pelvic volume in an open-book fractured pelvis. In addition, it would not be logical to assess pelvic volume in healthy volunteers as the volume of an unfractured pelvis would remain static.

A limitation of the study is that a single 'patient' was used throughout, and we cannot be sure what the effect of a different body habitus or pelvic shape might have on the transferability of the results. In our pilot study, to assess the magnitude of the difference between devices, two further members of the study group were used as 'patients' and our findings were consistent with those seen in the study.

The trochanteric pressure generated was measured at 2 min as the feasibility study showed that after this time any relaxation of the pressure-generating device/sheet had plateaued with no significant further loss in pressure beyond this time.

Whilst one case report indicates a possible clinical benefit describing anteriorly clamping a neatly folded sheet around the pelvis after tightening between two physicians, there is no formal instruction or specific technique associated with the application of a bed sheet as a tool for pelvic compression within the ATLS guidance.[20] The resultant techniques used to

apply the bed sheet varied widely. The most common technique was to apply a simple knot with a neatly folded sheet applied across the greater trochanters. The lack of consistent application of this compression tool is consistent with the lack of instruction within both the literature and ATLS guidance. In comparison, instructions for application are present on the individual packaging of each SAM sling.

As the aim of the study was to measure pressures generated by correctly applied devices, participants were reminded of the appropriate landmarks. Having the saline pressure transducers visible overlying the greater trochanters ensured that the correct landmarks were used, and reduced any influence of operator misapplication that would result from being unaware of the correct application technique. ATLS does not teach a specific way to apply a bed sheet for pelvic compression. Therefore, in order to accurately reflect a real clinical scenario, participants were given each pelvic compression tool with no further instruction beyond the anatomical landmarks.

It is possible that the bed sheet pressures generated may have a clinical beneficial impact, though given that the PCCDs are designed to most effectively reduce pelvic ring fractures it is unlikely that the bed sheet can reliably attain and maintain the same clinical effect. This standard of care would be unacceptable in all, but the most resource-poor settings.

Bed sheets are cheap, ubiquitous in the in-patient setting and reusable. Their use would require almost no further input of resources. PCCDs, in comparison, cost approximately £50 per unit and are recommended as single use only. Bed sheets may provide some benefit and, as they are unlikely to harm, they could reasonably be used in low-resource setting where commercial PCCDs are unavailable. Given the overall cost implications of trauma admissions, however, they would not represent a significant cost implication in most modern health care settings. They may possibly reduce costs by reducing the need for blood transfusions or by improving clinical outcomes.

Conclusion

In patients with a suspected pelvic fracture, a bed sheet is unable to consistently generate pressures approaching those of a commercially available PCCD.

Funding

No external funding was required for this study.

Conflict of interests

The authors declare that there is no conflict of interest.

Acknowledgments

The authors would like to acknowledge the work of Dr Michael Wallace, Dr Emma Stewart and Dr Liz Cervi for providing assistance in this research.

Provenance and peer review

Not commissioned, externally peer reviewed.

References

1. National Confidential Enquiry into Patient Outcome and Death. *Trauma: Who cares?* London: NCEPOD, 2007.
2. Mohanty K, Musso D, Powell JN, et al. Emergent management of pelvic ring injuries: an update. *Can J Surg [Internet]* 2005; 48: 49–56.
3. Dalal SA, Burgess AR, Siegel JH, et al. Pelvic fracture in multiple trauma: classification by mechanism is key to pattern of organ injury, resuscitative requirements, and outcome. *J Trauma* 1989; 29: 981–1000, discussion 1000–2.
4. McMurtry R, Walton D, Dickinson D, et al. Pelvic disruption in the polytraumatized patient: a management protocol. *Clin Orthop Relat Res* 1980; 151: 22–30.
5. Moreno C, Moore EE, Rosenberger A, et al. Hemorrhage associated with major pelvic fracture: a multispecialty challenge. *J Trauma* 1986; 26: 987–994.
6. Heckbert SR, Vedder NB, Hoffman W, et al. Outcome after hemorrhagic shock in trauma patients. *J Trauma* 1998; 45: 545–549.
7. Gilliland MD, Ward RE, Barton RM, et al. Factors affecting mortality in pelvic fractures. *J Trauma* 1982; 22: 691–693.
8. Paterson F and Morton K. The cause of death in fractures of the pelvis. *J Trauma* 1973; 13: 849–856.
9. Rothenberger D, Fischer R, Strate R, et al. The mortality associated with pelvic fractures. *Surgery* 1978; 84: 356–361.
10. Sevitt S. Fatal road accidents: injuries, complications and causes of death in 257 subjects. *Br J Surg* 1968; 55: 481–505.
11. Routt ML, Simonian PT and Ballmer F. A rational approach to pelvic trauma. Resuscitation and early definitive stabilization. *Clin Orthop Relat Res* 1995; 318: 61–74.
12. Heini PF, Witt J and Ganz R. The pelvic C-clamp for the emergency treatment of unstable pelvic ring injuries. A report on clinical experience of 30 cases. *Injury* 1996; 27: S–A38–A45.
13. Huittinen V and Slatis P. Post mortem angiography and dissection of the hypogastric artery in pelvic fractures. *Surgery* 1973; 73: 454–462.
14. American College of Surgeons Committee on Trauma. *Advanced trauma life support for doctors*. 9th ed. 2012.
15. Simpson T, Krieg JC, Heuer F, et al. Stabilization of pelvic ring disruptions with a circumferential sheet. *J Trauma* 2002; 52: 158–161.
16. Bottlang M, Krieg JC, Mohr M, et al. Emergent management of pelvic ring fractures with use of

circumferential compression. *J Bone Joint Surg Am* 2002; 84-A: 43–47.
17. Prasarn ML, Conrad B, Small J, et al. Comparison of circumferential pelvic sheeting versus the T-POD on unstable pelvic injuries: a cadaveric study of stability. *Injury* 2013; 44: 1756–1759.
18. Radvinsky DS, Yoon RS, Schmitt PJ, et al. Evolution and development of the Advanced Trauma Life Support (ATLS) protocol: a historical perspective. *Orthopedics* 2012; 35: 305–311.
19. Mohammad A, Branicki F and Abu-Zidan FM. Educational and clinical impact of Advanced Trauma Life Support (ATLS) courses: a systematic review. *World J Surg* 2014; 38: 322–329.
20. Routt MLC, Falicov A, Woodhouse E, et al. Circumferential pelvic antishock sheeting: a temporary resuscitation aid. *J Orthop Trauma* 2002; 16: 45–48.
21. Bottlang M, Simpson T, Sigg J, et al. Noninvasive reduction of open-book pelvic fractures by circumferential compression. *J Orthop Trauma* 2002; 16: 367–373.