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Kendrick's extrication device and unstable pelvic fractures: Should a trochanteric belt be added? A cadaveric study

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ABSTRACT

Introduction: Pre-hospital pelvic stabilisation is advised to prevent exsanguination in patients with unstable pelvic fractures (UPFs). Kendrick's extrication device (KED) is commonly used to extricate patients from cars or crevasses. However the KED has not been tested for potential adverse effects in patients with pelvic fractures. The aim of this study was to examine the effect of the KED on pubic symphysis diastasis (SyD) with and without the use of a trochanteric belt (TB) during the extraction process following a MVC.

Materials and methods: Left-sided "open-book" UPFs were created in 18 human cadavers that were placed in seven different positions simulating pre-extraction and extraction positions using the KED with and without a TB in two different positions (through and over the thigh straps). The SyD was measured using anteroposterior radiographs. The effects of the KED with and without TB, on the SyD, were evaluated.

Results: The KED alone resulted in a non-significant increase of the SyD compared to baseline, whereas the addition of a TB to the KED resulted in a significant reduction of the SyD ($p < 0.001$). The TB through the straps provided a significantly better reduction than the TB over the straps in the extracted position ($p < 0.05$).

Conclusion: Our study demonstrated that a TB in combination with the KED on UPFs is an effective way to achieve early reduction. The addition of the TB in combination with the KED could be considered for Pre-Hospital Trauma Life Support (PHTLS) training protocols.

Introduction

Unstable pelvic fractures (UPFs) represent less than 3% of all fractures in the general population [1–4], and are often the result of high-energy mechanisms of injury, usually due to motor vehicle collisions (MVCs) [5–10]. They affect almost 10% of trauma patients [8,11] and death resulting directly from pelvic trauma is considered to occur in 1% of patients [6,12,13]. However, when pelvic trauma is combined with other injuries, mortality can range from 4–46% [3,6,10,12,14–18]. Moreover mortality is probably underestimated because patients who die before they reach the hospital are not included in epidemiological studies [19]. One of the major factors increasing mortality (up to four times) in UPFs is haemodynamic instability [7,9]. Indeed, the most common cause of mortality in pelvic ring fractures is haemorrhage [10,18], and early pelvic stabilisation is advised to prevent exsanguination in these patients [20].

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Kendrick's extrication device (KED) is commonly used to extricate patients from crashed cars [21] or crevasses [22]. Nevertheless, the KED has never been tested for potential adverse effects in patients with pelvic trauma, especially since the conformation of the thigh straps could lead to an increase in the symphysis diastasis (SyD) in open book fractures. Given the serious potential complication of SyD widening, leading to exacerbation of the haemorrhage and haemodynamic instability [20], it is critical to assess the effect of the KED on UPFs by using an anatomic model.

The aim of this study was to examine the effect of the KED on the SyD, with and without the use of a trochanteric belt (TB) in different positions simulating extrication of subjects with UPFs after MVCs. We hypothesised that the use of the KED without a TB could increase the SyD, and that adding a TB could prevent this increase, or even result in a reduction of the SyD during the extrication. We also hypothesised that the belt's position, either through or over the KED's thigh straps, could be relevant.

Materials and methods

Study Population

We performed a cadaveric study examining the effects of the KED (Attelle cervico-thoracique CED 3C, Corben, Le Havre, France) on the SyD of subjects with UPFs when used alone or in combination with a TB (Trochanteric belt, Dimatex Sécurité, Fleurieux sur l'Arbresle, France). Eighteen human cadavers (9 male, 9 female) without known history of pelvic fractures were used. Ages ranged from 56 to 100 years, (mean 85.8 years), heights ranged from 143 to 178 centimetres (cm) (mean 161 cm), and weights ranged from 36.5 to 78.5 kilograms (kg) (mean 51.8 kg). All cadavers were embalmed forty-eight to seventy-two hours post mortem, at room temperature, using an embalming solution (Safe Balm®, Hygeco PMA, St Priest, France) that did not alter tissue softness. All experiments were conducted at the Laboratory of Anatomy of the Faculty of Medicine of Lyon Est (France), in strict accordance with French laws and regulations. Corpses came from donors who had willingly donated their corpses during their lifetime by testament to the Science for teaching and research purposes.

Study protocol

A midline incision was performed on each cadaver using a 23-blade scalpel, extending from 4 cm below the xiphoid process to anterior to the symphysis pubis, and the subcutaneous tissue was divided using Mayo scissors. The incision was carried down through the linea alba and the peritoneum was entered, taking care not to disrupt the intraperitoneal contents. The left sacroiliac joint was exposed by dissecting the presacral fascia of the sacral promontory medial to the iliac vessels. The sacroiliac joint was then completely disrupted using an osteotome and a hammer. The fascia around the symphysis pubis was dissected using both blunt and sharp dissection, and the symphysis pubis was then disrupted using an osteotome and a hammer. A rib spreader was used to widen the symphysis pubis to 8 cm to replicate soft tissue shearing forces associated with "open book" UPFs (OTA fracture classification 61-C1 [23]). A 12 millimetres (mm) radio-opaque ball bearing was placed in an incision in the soft tissue 2 cm lateral to the symphysis pubis, and sutured into place, to serve as a size reference for radiographic measurements. Abdominal skin and subcutaneous tissue were closed with 0 Vicryl® suture (Ethicon, Issy les Moulineaux, France).

The cadavers were positioned in seven different positions to simulate a pre-extrication (baseline) position and six extrication positions with the KED (with or without a TB). "Baseline position" was defined as seated without any extrication or binding device attached. "Seated KED position" was defined as seated with all KED straps fastened. "Extraction KED position" was defined as elevation of the cadaver using a cable attached to the superior loop of the KED until the cadaver's feet did not touch the ground or the chair anymore. "Trochanteric belt placement" was defined as placement of a TB around the lower extremities as close to the greater trochanters as would be possible for MVC patients in the seated position (i.e. as close to the greater trochanters as could be attained on a seated cadaver using two people to attach the belt). A 4-cm wide, flexible, non-elastic TB was used in two positions: "Trochanteric Belt Placement 1 (TBP1)" was defined as having the trochanteric belt placed and fastened through the thigh straps of the KED. "Trochanteric Belt Placement 2 (TBP2)" was defined as having the trochanteric belt placed and fastened over the thigh straps of the KED (Fig. 1).

The positions examined, in order, were: (1) baseline position, (2) seated position with KED alone, (3) extraction position with KED alone, (4) seated position with KED and TBP1, (5) extraction position with KED and TBP1, (6) seated position with KED and TBP2, and (7) extraction position with KED and TBP2. The pelvis was reset to baseline position once before applying the TB in TBP1 (position 4) and once more before applying the belt in TBP2 (position 6), to minimise any possible effect of the previous positions on the following ones. The resetting was performed by seating the cadaver, unfastening all of the KED straps and rocking the pelvis.

For every position, an antero-posterior (AP) pelvic digital radiograph was performed. The SyD width was then calculated in mm using the 12 mm radio-opaque ball bearing as a size reference. The measurements were performed with PhotoShop CC 15 (Adobe, San Jose, CA, USA) (Fig. 2).

Nine comparisons between the different positions were performed (Table 1), to answer the following questions: (1) What was the effect of the KED alone on the SyD during the extrication process? (2) What was the effect of the KED, when combined with the TB, on the SyD during the extrication process? (3) Was there a significant difference in the SyD between the two belt positions?

Statistical analysis

For each position, the median and interquartile range of the SyD were calculated. The proportion of subjects that demonstrated an increase in SyD when compared to baseline and the corresponding 95% confidence interval (CI) [24] were calculated as well for each position. For each subject, the baseline SyD was subtracted from the SyD of the other positions. The different positions were then compared with Wilcoxon's test for paired samples. The Hodges–Lehmann estimator was used to calculate the pseudomedian [25], a point estimate of the difference between the two groups being compared. The corresponding 95% CIs were calculated as well [26]. Statistical significance was set at $p = 0.05$ (two-tailed). No correction for multiple comparisons was performed. Data were analysed with Rv3.1.3 for Windows.

Results

The protocol was successfully performed on all the cadavers. The results are presented in Tables 1, 2 and Fig. 3. In the following paragraphs CI of proportions are presented as [CI] and the results of the Wilcoxon test for paired samples are presented jointly with the pseudomedian.

Overall, the KED alone did not result in a significant increase of the SyD during the extraction process (Extracted vs. Baseline position [0.6 mm, $p = 0.799$], Extracted vs. Seated position [−0.6 mm, $p = 0.766$] and Seated vs. Baseline [0.6 mm, $p = 0.67$]).