Injury, Int. J. Care Injured 48 (2017) 26–31

Contents lists available at ScienceDirect

Injury

journal homepage: www.elsevier.com/locate/injury

Bi-manual proximal external aortic compression after major abdominal-pelvic trauma and during ambulance transfer: A simulation study

M.J. Douma[a], D. O'Dochartaigh[b], P.G. Brindley[c,*]

[a] Royal Alexandra Hospital Emergency Department, Alberta Health Services, Canada
[b] Edmonton Zone Emergency Departments, Alberta Health Services, Canada
[c] Department of Critical Care Medicine, University of Alberta Hospital, Edmonton, Alberta, Canada

ARTICLE INFO

Keywords:
Noncompressible torso hemorrhage
Junctional hemorrhage
Prehospital care

ABSTRACT

Background: Applying manual pressure after hemorrhage is intuitive, cost-free, and logistically-simple. When direct abdominal-pelvic compression fails, clinicians can attempt indirect proximal-external-aortic-compression (PEAC), while expediting transfer and definitive rescue. This study quantifies the sustainability of simulated bi-manual PEAC both immediately on scene and during subsequent ambulance transfer. The goal is to understand when bi-manual PEAC might be clinically-useful, and when to prioritize compression-devices or endovascular-occlusion.
Methods: We developed a simulated central vessel compression model utilizing a digital scale and Malbrain intra-abdominal pressure monitor inside a cardiopulmonary resuscitation mannequin. Twenty prehospital health care professionals (HCPs) performed simulated bimanual PEAC i) while stationary and ii) inside an 80 km/h ambulance on a closed driving-track. Participants compressed at "the maximal effort they could maintain for 20 min". Results were measured in mmHg applied-pressure and kilograms compressive-weight. The Borg scale of perceived-exertion was used to assess sustainability, with <16 regarded as acceptable.
Results: While stationary all participants could maintain 20 min of compressive pressure/weight: within five-percent of their starting effort, and with a Borg-score <16. Participants applied 88–300 mmHg compression pressure; (mean 180 mmHg), 14–55 kg compression-weight (mean 33 kg), and 37–66% of their bodyweight (mean 43%). In contrast, participants could not apply consistent or sustained compression in a moving ambulance: Borg Score exceeded 16 in all cases.
Conclusions: Survival following major abdominal-pelvic hemorrhage requires expedited operative/interventional rescue. Firstly, however, we must temporize pre-hospital exsanguination both on scene and during transfer. Despite limitations, our work suggests PEAC is feasible while waiting for, but not during, ambulance-transfer. Accordingly, we propose a chain-of-survival that cautions against over-reliance on manual PEAC, while supporting pre-hospital devices, endovascular occlusion, and expeditious but safe hospital-transfer.

Introduction

Following life-threatening hemorrhage the goal is to temporize blood-loss and expedite definitive-rescue. Junctional trauma-namely, that which occurs between the inguinal ligament and umbilicus; encompasses the groin, buttocks, pelvis and perineum; and is also known as non-compressible torso and abdominal-pelvic hemorrhage- is a leading cause of potentially survivable mortality [1]. Previously, few temporizing strategies existed beyond direct pressure [2], hemostatic dressings [3,4], and hypotensive resuscitation [5]. Recently, there is growing interest in torso or junctional tourniquets [6] and endovascular devices (including Resuscitative Endovascular Balloon Occlusion of the Aorta [7] (REBOA)). Devices offer great potential but also cost money, require instruction, take time to apply, are not stored on most ambulances, and, in the case of REBOA, require specialized pre-hospital staff.

There is also interest in manual proximal-external-aortic-compression (PEAC) [8]. This is because it can be immediately

* Corresponding author.
E-mail addresses: matthew.douma@albertahealthservices.ca (M.J. Douma), peter.brindley@ahs.ca (P.G. Brindley).

http://dx.doi.org/10.1016/j.injury.2016.11.003
0020-1383/

applied, requires minimal instruction, is cost-free, and has been successful in diverse settings such as post-partum hemorrhage [9], and ruptured abdominal aortic aneurysm [10]. The manoeuvre is performed by making a fist, covering it with a second hand, extending the elbows and bringing the shoulders above as though performing chest compressions, but with consistent downward pressure. The umbilicus is often used as a landmark for the abdominal aorta proximal to the bifurcation to the common femoral arteries. However, over 80 lbs (36 kg) of compressive weight may be required to arrest blood flow in the abdominal aorta [11] and though this is feasible for some healthcare professionals (HCPs) [12], PEAC may be optimized by keeping the patient in a low position, using two hands and compressing atop a hardboard [13].

The purpose of this study is to determine whether manual PEAC can be i) sustained while awaiting assistance and ii) during pre-hospital transfer. Accordingly, this study could have implications for the chain-of-survival following major junctional trauma [14].

Methods

Study design

This was a prospective, crossover simulation study of compression sustainability i) stationary on cement floor and ii) during ambulance transport. Participants independently completed scripted scenarios, and performed the crossover the same day. Study participants were blinded to their own and others' compressive weight and pressure, and were instructed to use bimanual PEAC to compress "with the maximum effort that they felt they could maintain for 20 min" (to mimic the time from ambulance dispatch-to-scene arrival, and subsequent transfer time from scene-to-hospital).

Recruitment

Volunteer prehospital HCPs were recruited from an optional unpaid continuing-education workshop. Participant-safety and participant-anonymity were required for approval from our Institutional Ethics Board. All participants provided written consent.

Simulation model

Our model (previously validated) consisted of a high-capacity medical weight scale (Seca, Hamburg), with a modified Malbrain intra-abdominal pressure monitoring system placed atop [13,15]. The model was inserted into the abdominal compartment of Resusci Anne Cardiopulmonary Resuscitation training manikin (Laerdal, Norway).

Data collection and analysis

Measurements were taken with the model placed in two locations: i) on a cement floor; ii) atop a rigid backboard (Ferno, Ohio) placed on a collapsed emergency medical services stretcher (Stryker, Michigan) that was secured to the ambulance floor. The second-set of measurements were taken while the ambulance was being driven around a closed-track at 80 km-per-hour (estimated as the speed of safe but expedited metropolitan patient transfer). Data was recorded electronically every 12 s for compression weight (kgs) and pressure (mmHg) using a Philips (Amsterdam) MRX Heartstart Monitor.

The Borg scale of perceived-exertion was used to assess participant effort: where 6–11 represents minimal effort, 12–16 represents sustainable exertion, and 16–20 represents non-sustainable exertion [16]. Measurements were transcribed into an electronic spreadsheet (Excel 2011; Microsoft, Washington). Mean results and descriptive statistics were calculated.

Results

A convenience sample of 20 HCPs performed the study protocol (4 females; 16 males; age 19–44 years; weight 43–110 kg). During stationary bimanual compression, participants compressed a mean of 33 kg (range 14–55 kg) or 43% of their bodyweight (range 33–63%). Average compression pressure was 178 mmHg (range 88–300 mmHg). Borg Scale perceived-exertion averaged 12.6 (rated as between "fairly light" and "somewhat hard") with a range from 10 to 14 (rated as "very light" to "somewhat hard"). Stationary weight compressed, percentage of clinician bodyweight, pressure in millimeters of mercury and Borg exertion scale data for each participant can be viewed in Table 1. Please refer to Fig. 1 for a line graph of participant compression while stationary.

Table 1
Average Participant Compression Characteristics While Stationary at Ground Level.

Participant	Average Percentage of Bodyweight Compressed (Range)	Average Weight Compressed (pounds)	Average Millimeters of Mercury Compressed	Borg Exertion Scale
1	42 (41–46)	27.7 (60.9)	150	13
2	41 (40–43)	39.1 (86.1)	212	13
3	40 (37–44)	31.8 (70)	175	13
4	36 (33–38)	25.4 (55.8)	137	12
5	45 (42–47)	24.5 (54)	133	13
6	33 (27–35)	32.6 (71.8)	88	12
7	50 (48–55)	27.2 (59.9)	147	13
8	40 (37–42)	25.5 (56)	138	13
9	33 (29–35)	26.4 (58.1)	156	13
10	38 (37–40)	32.6 (71.8)	177	13
11	40 (38–43)	28 (61.6)	152	14
12	51 (47–54)	34.3 (75.5)	192	13
13	45 (41–47)	49.1 (108)	272	12
14	37 (33–39)	36.2 (79.6)	196	11
15	55 (50–57)	55 (121)	300	10
16	40 (38–44)	29.6 (65.2)	161	13
17	45 (41–48)	35.7 (78.5)	195	12
18	63 (60–65)	41 (90.1)	222	13
19	41 (38–43)	35.3 (77.7)	191	13
20	46 (44–48)	37.7 (83)	199	13