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Pressure Exerted Using a Pelvic Binder

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Abstract

Background: Pelvic Circumferential Compression Device (PCCDs) aids in temporary stabilisation of pelvic injuries, in a decrease of pelvic volume and thereby assisting in haemostasis. It is known that if PCCDs are applied for extended duration, damage to tissue can occur. This research helps to quantify the pressure exerted by two different PCCD (SAM Sling® and T-POD®) at four locations (anterior, right, left and sacral) in healthy volunteers.

Methods: SAM sling® and T-POD® were applied randomly on healthy volunteers and mean pressures was measured at locations (anterior, right, left and sacral) by pressure cuffs.

Results: A significant variation was noted in the pressure exerted by both PCCDs at the four locations. Pressures exerted at anterior locations were less than tissue damaging pressure of 9.3 kPa for both SAM Sling® and T-POD®. For volunteers with higher BMI the pressure exerted at right and left greater trochanter was greater than the tissue damaging pressure of 9.3 kPa for both SAM Sling® and T-POD®. However, the SAM-Sling® produced higher mean pressures on the left location as compared to the right location while T-POD® produced higher mean pressures on the right location as compared to the left location. This can be attributed to the different closing mechanism of both the PCCDs. Pressure exerted at the sacral location was always greater than the tissue damaging pressure of 9.3 kPa for both the PCCDs.

Conclusion: The results of this study in healthy volunteers presented that application of PCCD is associated with the development of high mean pressure at the right greater trochanter, left greater trochanter and sacral region and may lead to formation of pressure sores. However further research with a higher number of volunteers and testing of the results of this study in acute clinical scenario is needed to ascertain these findings from the current study.

Keywords: SAM sling®; Pelvic Binder; Pelvic Circumferential Compression Device (PCCDs)

Abbreviations

ATLS: Advanced Trauma Life Support; BMI: Body Mass Index; DCS: Damage Control Surgery; PCCD: Pelvic Circumferential Compression Device; WC: Waist Circumference

Introduction

The incidence of pelvic fractures is increasing in trauma population, especially high velocity trauma and most pelvic injuries are result of polytrauma. Dimitriou and Giannoudis [1] emphasised

the severity pattern of these injuries, ranging from less velocity injury, which are clinically manageable, to higher velocity injury, which can deteriorate rapidly and result in substantial mortality and morbidity. Resuscitation in such a polytraumatised patient is aimed toward achieving cardiopulmonary and circulatory hemostasis, especially within the 'first hour' [2]. Meighan., *et al.* [2], also concluded that immobilisation of the pelvic ring is both a requirement and a critical measure in unstable pelvic fracture with circulatory loss from an unidentified cause, the shock is assumed secondary to the pelvic injury until proved otherwise.

External compression to the pelvis provides a rapid, non-invasive, easy, and effective reduction and immobilisation of pelvic injuries by a biomechanical approach. A commonly used type of external pelvic compression is a Pelvic Circumferential Compression Device (PCCD), which consists of a strap around the pelvic area and is tensioned with the closing mechanism and hence decreases the pelvic volume and closing the pelvic ring. Ghaemmaghami V [3] highlighted the importance of reducing pelvic volume which successively stops bleeding by the mechanisms of tamponade, clotting and hemostasis. Diminished movements of fracture fragments due to closure of the pelvic ring successively leads to a decreased oozing from fracture fragments [4]. At present, three commercially available non-invasive external compressive devices are available (Pelvic Binder®, T-POD® and SAM Sling®) (Figures 1, 2, and 3) and are helpful in both pre-hospital and hospital scenarios with suspected pelvic fractures and they help in optimising the circulatory state of the patient especially within the crucial ‘first hour’ [2,5]. Advanced Trauma Life Support (ATLS) guidelines recommend the use of a pelvic binder in a polytrauma patient with suspected pelvic injury.

When the pelvic binder is applied, the bony prominences are subjected to marked compressive forces [6]. Literature on the usefulness and potential adverse effects of pelvic binders is scarce. Material, size, shape and closing mechanism vary in all commercially available pelvic binders which in turn causes a variance in biomechanical effects. Since pelvic binders are applied manually, the pulling forces are uninhibited, except in the SAM-Sling®, which consists of an auto-stop buckle that limits the applied forces to 150N. The uninhibited forces lead to unknown pressure build-up on the pelvis and thereby its outcome on the skin is uncertain. Extended use of a pelvic binder before definite pelvic fixation has been found to have adverse effects mainly pressure induced skin breakdown. Hedrick-Thompson [7] documented that if a constant pressure above 9.3 kPa is applied for greater than two or three hours, it may lead to tissue damage. For maintaining circulation to the skin it is suggested that a pressure be kept beneath the capillary blood pressure that is below 4.66 kPa [6,7].

This present study intends to measure the quantitative pressure exerted by two commonly available external compression devices (SAM Sling® and T-POD®) on healthy individuals. This may contribute in identifying the patients with high risk of development of pressure sores, to formulate guidelines for appropriate and safe use of pelvic binders and in future research.

Aims and Objectives

The aim of the study was to quantify the pressure exerted by two types of pelvic binder, and to compare repeatability.

The objectives were to determine if there was a variation in pressure exerted by the two types of pelvic binders on anterior, right lateral, left lateral and sacral areas in following situations:

- When pelvic binder was applied correctly in supine position
- When pelvic binder was applied to healthy volunteers of different BMI and waist circumference

Literature Review

Pelvic fractures generally seen in polytrauma due to high velocity injuries and leading to massive haemorrhage which can be due to bleeding from the fracture ends or bleeding from the venous or arterial systems [8]. Often a failure in resuscitating the patient particularly in the ‘first hour’ is the reason for the high mortality associated with pelvic fractures and therefore pre-hospital stabilisation of such fractures is strongly recommended by Advanced Trauma Life Support (ATLS) and Damage Control Surgery (DCS). Early cessation of bleeding is the most effective resuscitative measure and can be rapidly achieved using a PCCD [9]. The external circumferential compression by PCCDs causes a decrease in pelvic volume and hence restricts the internal blood loss.

The three most commonly used PCCDs are the Pelvic Binder®, SAM Sling® and the T-POD®.

Type of pelvic binder	Pelvic Binder®	SAM-Sling®	Trauma Pelvic Orthotic Device (T-POD)®
Size	Single size	3 sizes	Single size
Closing mechanism	Shoelace mechanism	Auto-stop buckle	Pulley system
Precautions	Two fingers gap between the patient and the pelvic binder	Two straps are pulled in opposite direction	Two fingers gap between the patient and the T-POD®

Table 1: Commercially available common Pelvic Circumferential Compression Device (PCCD).

Figure 1: Pelvic Binder - <https://www.pelvicbinder.com/pelvicbinder>.

Figure 2: SAM Sling® - <https://www.sammedical.com/products/pelvic-sling>.

Figure 3: T-POD® - <https://www.teleflex.com/usa/en/product-areas/emergency-medicine/trauma/arrow-t-pod/index.html>.

The pressure exerted by all three types of pelvic binder is different owing to the difference in the design and closing mechanism of each design. The pelvic binder has a shoelace mechanism, SAM

Sling® consists of an auto-stop buckle (at 150N), and the T-POD® has a pulley system. The two straps of the SAM-Sling® should be drawn in opposite directions and therefore the left side is exposed to higher forces than the right side. In comparison with other pelvic binders the SAM-Sling® is small which gives advantageous clinical or surgical access to the abdomen, although the small size of SAM-Sling® predisposes it to be displaced at the greater trochanters. The mechanical advantage pulley system of the T-POD® requires less pulling force to achieve simultaneous circumferential compression. The T-POD® design allows it to be pulled in opposite directions thereby accounting for slightly higher right mean pressures. It is worth noting that the fastener strings of the T-POD® lead to higher anterior pressure which could clinically lead to development of vascular compromise to the skin, more commonly so in obese individuals.

Sacral pressure will be a summation of body weight and pressure exerted by PCCD and clinically this will be higher than all other locations.

Croce., *et al.* [10] in their case-control study compared non-invasive PCCD and invasive pelvic stabilisation for management of pelvic fractures. They recommended that use of PCCD decreased the ongoing blood loss and hence resulted in lower transfusion requirements [10].

There is a relation between decubitus risk and BMI and literature data indicates that the excess fat diminishes the hazard of skin ulcer. Jowett and Bowyer [11], studied the pressure exerted by PCCD and demonstrated an inverse correlation with the BMI.

Knops., *et al.* [12] concluded that irrespective of the type of PCCD used, pressure exerted by PCCD applied to the patient on a spine board far exceeds that of hospital bed. Therefore, to decrease the pressure exerted it is of paramount importance to shift the patient from a spine board [12].

Bottlang., *et al.* [13] highlighted the importance of placement of PCCD at the level of the greater trochanter and tensioning them to 180N for optimal reduction of pelvic fractures.

In a systematic review Spanjersberg., *et al.* [14] suggested that although PCCDs are efficient in fracture reduction and thereby decreasing the associated haemorrhage, where the accompanying adverse effects consist of pressure sore and damage to inner milieu.

It is noted that polytrauma patients are often immobilised on spine boards, which is a possible risk factor for developing pressure sores. Pressure sores can be considered as possibly preventable complications of acute immobilisation. Pressure above 9.3kPa sustained continuously for more than 2 to 3 hours often cause tissue damage in the form of pressure sores and skin necrosis [6]. Type of pelvic binder, age, waist circumference, BMI and gender all influence the pressure exerted upon the skin. Knops, *et al.* [12] emphasised the need to prevent over-tensioning of pelvic binder; avoid extended use and to frequently monitor the skin.

Materials and Methods

Study design

After obtaining Dundee University Ethical approval, nine healthy volunteers aged 20 to 50 years, lacking a past history of pelvic or back complaints were recruited in the study. All volunteers were thoroughly explained about the nature of the procedure verbally and by participant information sheets and the volunteers were given 24 hours to choose whether or not to participate in the study. Each volunteer was requested to sign an informed consent form before the start of the process. Two commonly used pelvic binders were tested: SAM-Sling® and T-POD®. The chief investigator applied these binders randomly.

Study process

Initial measurements for all volunteers included body mass index (BMI) and waist circumference. Four small size non-invasive oscillometric blood pressure cuffs with attached pressure gauge were placed anteriorly, over the right greater trochanter, over the left greater trochanter and over sacral region and then randomly pelvic binder (PCCDs) were applied over the blood pressure cuffs and tightened as per manufacturers' guidelines above the volunteers normal clothing. Cuffs remained central in position when the pelvic binders were applied over the top of them. After applying and releasing of PCCDs the pressure cuffs returned to the baseline pressure thus proving the elastic nature of the cuffs. Three sets of readings were taken for each measurement. For obtaining the most accurate pressure readings a time gap of 30 minutes was given between two measurements. The reading was taken with volunteer in a supine position on a bed. In order to measure in a standardised way, the PCCDs were pulled tight with a horizontal pulling force at the tangents of the closing mechanism. The SAM-Sling® was pulled tight with two hands in opposite directions and one hand was used to pull the T-POD® towards right side. Three sets of readings were taken for each measurement.

Measurements were done and data were recorded in the following format (Table 2).

Subject, BMI =, WC =				
Pelvic Binder 1 = SAM Sling®				
Supine	Anterior	L.GT	R.GT	Sacral
Pelvic Binder 2 = T-POD®				
Supine	Anterior	L.GT	R.GT	Sacral

Table 2: Format for recording of findings.

*L.GT = Left Greater Trochanter; R. GT = Right Greater Trochanter.

Results

Subjects	Age (years)	Gender	BMI (kg/m ²)	WC (inch)
1	31	Female	20.3	27
2	25	Female	29.3	36.5
3	45	Male	31.9	39
4	27	Male	27.89	36
5	23	Male	31.96	39.5
6	30	Male	25.4	37
7	24	Female	22.3	32
8	32	Male	25.8	34
9	30	Female	21.2	28

Table 3: Demographic description of study population.

Figure 4: Demographic description of study population.

A demographic description of the study population is shown in table 3 and figure 4. The study consisted of 5 male and 4 female volunteers. The participants had a mean age of 29.6 ± 6.21 years and a BMI of 26.22 ± 4.19 kg/m².

BMI = 20.2, WC = 27"				
Pelvic Binder 1 = SAM Sling®				
Supine	Anterior	L.GT	R.GT	Sacral
	24 / 32 / 26 (27.33)	42 / 50 / 52 (48)	40 / 44 / 42 (42)	84 / 100 / 94 (92.66)
Pelvic Binder 2 = T-POD®				
Supine	Anterior	L.GT	R.GT	Sacral
	18 / 20 / 18 (18.66)	72 / 64 / 92 (76)	78 / 96 / 74 (78.66)	88 / 66 / 80 (78)

Table 4: Pressure reading of Subject 1 in mmHg (mean value). BMI: Body Mass Index; WC: Waist Circumference; R: Right; L: Left; GT: Greater Trochanter.

BMI = 29.3, WC = 36.5"				
Pelvic Binder 1 = SAM Sling®				
Supine	Anterior	L.GT	R.GT	Sacral
	34 / 36 / 34 (34.66)	50 / 58 / 60 (56)	50 / 54 / 60 (54.66)	126 / 126 / 120 (124)
Pelvic Binder 2 = T-POD®				
Supine	Anterior	L.GT	R.GT	Sacral
	20 / 30 / 24 (24.66)	82 / 76 / 80 (79.33)	88 / 88 / 90 (88.66)	94 / 112 / 120 (108.66)

Table 5: Pressure reading of Subject 2 in mmHg (mean value). BMI: Body Mass Index; WC: Waist Circumference; R: Right; L: Left; GT: Greater Trochanter.

BMI = 31.99, WC = 39"				
Pelvic Binder 1 = SAM Sling®				
Supine	Anterior	L.GT	R.GT	Sacral
	42 / 40 / 52 (44.66)	70 / 74 / 78 (74)	62 / 66 / 62 (63.33)	138 / 144 / 148 (143.33)
Pelvic Binder 2 = T-POD®				
Supine	Anterior	L.GT	R.GT	Sacral
	34 / 30 / 32 (32)	92 / 82 / 90 (88)	96 / 96 / 90 (94)	130 / 128 / 122 (126.66)

Table 6: Pressure reading of Subject 3 in mmHg (mean value). BMI: Body Mass Index; WC: Waist Circumference; R: Right; L: Left; GT: Greater Trochanter.

BMI = 27.89, WC = 36"				
Pelvic Binder 1 = SAM Sling®				
Supine	Anterior	L.GT	R.GT	Sacral
	32 / 38 / 40 (36.66)	62 / 68 / 60 (63.33)	60 / 62 / 60 (62)	130 / 122 / 148 (133.33)
Pelvic Binder 2 = T-POD®				
Supine	Anterior	L.GT	R.GT	Sacral
	30 / 38 / 32 (33.33)	84 / 80 / 54 (72.66)	82 / 70 / 76 (76)	128 / 122 / 120 (123.33)

Table 7: Pressure reading of Subject 4 in mmHg (mean value). BMI: Body Mass Index; WC: Waist Circumference; R: Right; L: Left; GT: Greater Trochanter.

BMI = 31.96, WC = 39.5"				
Pelvic Binder 1 = SAM Sling®				
Supine	Anterior	L.GT	R.GT	Sacral
	50 / 54 / 52 (52)	74 / 70 / 68 (70.66)	70 / 68 / 72 (68)	142 / 152 / 150 (148)
Pelvic Binder 2 = T-POD®				
Supine	Anterior	L.GT	R.GT	Sacral
	30 / 34 / 32 (32)	90 / 94 / 102 (95.33)	96 / 108 / 104 (102.66)	140 / 138 / 132 (136.66)

Table 8: Pressure reading of Subject 5 in mmHg (mean value). BMI: Body Mass Index; WC: Waist Circumference; R: Right; L: Left; GT: Greater Trochanter.

BMI = 25.4, WC = 37"				
Pelvic Binder 1 = SAM Sling®				
Supine	Anterior	L.GT	R.GT	Sacral
	30 / 36 / 32 (32.66)	66 / 68 / 64 (66)	50 / 58 / 54 (54)	132 / 138 / 130 (133.33)
Pelvic Binder 2 = T-POD®				
Supine	Anterior	L.GT	R.GT	Sacral
	20 / 30 / 30 (26.66)	72 / 70 / 84 (75.33)	88 / 80 / 82 (83.33)	130 / 122 / 118 (123.33)

Table 9: Pressure reading of Subject 6 in mmHg (mean value). BMI: Body Mass Index; WC: Waist Circumference; R: Right; L: Left; GT: Greater Trochanter.

BMI = 22.3, WC = 32"				
Pelvic Binder 1 = SAM Sling®				
Supine	Anterior	L.GT	R.GT	Sacral
	28 / 24 / 30 (27.33)	60 / 68 / 62 (63.33)	52 / 50 / 48 (50)	122 / 130 / 124 (125.33)
Pelvic Binder 2 = T-POD®				
Supine	Anterior	L.GT	R.GT	Sacral
	30 / 22 / 26 (26)	70 / 74 / 70 (71.33)	76 / 72 / 74 (74)	108 / 116 / 122 (115.33)

Table 10: Pressure reading of Subject 7 in mmHg (mean value). BMI: Body Mass Index; WC: Waist Circumference; R: Right; L: Left; GT: Greater Trochanter.

BMI = 25.8, WC = 34"				
Pelvic Binder 1 = SAM Sling®				
Supine	Anterior	L.GT	R.GT	Sacral
	38 / 30 / 32 (33.33)	64 / 70 / 68 (67.33)	56 / 60 / 52 (56)	134 / 140 / 130 (101.33)
Pelvic Binder 2 = T-POD®				
Supine	Anterior	L.GT	R.GT	Sacral
	26 / 28 / 30 (28)	72 / 70 / 78 (73.33)	82 / 82 / 84 (83.33)	130 / 126 / 120 (125.33)

Table 11: Pressure reading of Subject 8 in mmHg (mean value). BMI: Body Mass Index; WC: Waist Circumference; R: Right; L: Left; GT: Greater Trochanter.

BMI = 21.2, WC = 28"				
Pelvic Binder 1 = SAM Sling®				
Supine	Anterior	L.GT	R.GT	Sacral
	20 / 26 / 22 (22.66)	54 / 50 / 52 (52)	40 / 42 / 40 (40.66)	122 / 100 / 104 (105.33)
Pelvic Binder 2 = T-POD®				
Supine	Anterior	L.GT	R.GT	Sacral
	16 / 18 / 20 (18)	58 / 60 / 64 (60.66)	76 / 70 / 80 (75.33)	100 / 104 / 102 (102)

Table 12: Pressure reading of Subject 9 in mmHg (mean value). BMI: Body Mass Index; WC: Waist Circumference; R: Right; L: Left; GT: Greater Trochanter.

No.	BMI (kg/m ²)	Anterior (mmHg)	Rt. Greater Trochanter (mmHg)	Lt. Greater Trochanter (mmHg)	Sacral (mmHg)
1	20.2	27.33	42	48	92.66
2	29.3	34.66	54.66	56	124
3	31.99	44.66	63.33	74	143.33
4	27.89	36.66	62	73.33	133.33
5	31.96	52	68	70.66	148
6	25.4	32.66	54	66	133.33
7	22.3	27.33	50	63.33	125.33
8	25.8	33.33	56	67.33	101.33
9	21.2	22.66	40.66	52	105.33

Table 13: Mean pressure reading - SAM Sling®. BMI: Body Mass Index; Rt: Right; Lt: Left.

Sam sling®

The average exerted pressure on the anterior location was 34.58 mmHg (4.61 kPa), on the right greater trochanter it was 54.51 mmHg (7.26 kPa), on the left greater trochanter it was 63.40 mmHg (8.45 kPa) and on the sacral location it was 122.96 mmHg (16.39 kPa).

Pressure at the anterior location

Figure 5: Relationship between BMI and anterior pressure – SAM Sling®.

Figure 6: Scatter plot demonstrating BMI and anterior pressure – SAM Sling®.

Figure 5 and 6 demonstrate the relation between BMI and the mean pressure exerted at anterior location. As depicted in figure 4, with higher BMI of the volunteers, the pressures exerted were higher and in volunteers with lower BMI, less pressure was exerted by SAM Sling®. It can be concluded from figure 4 and 5 that the pressure exerted on anterior location were less than tissue damaging pressure of 9.3 kPa (69.75 mmHg).

Pressure at the right greater trochanter

Figure 7: Relationship between BMI and right greater trochanter pressure – SAM Sling®.

Figure 8: Scatter plot demonstrating BMI and Rt. greater trochanter pressure – SAM Sling®.

Figure 7 and 8 demonstrate the relation between BMI and the mean pressure exerted at right greater trochanter location. As depicted in figure 7, with higher BMI of the volunteers, the pressures exerted were higher and in volunteers with lower BMI, less pressure was exerted by the SAM Sling®. Figure 7 clearly depicts that in volunteers with higher BMI the pressure exerted on right greater trochanter was more than the tissue damaging pressure of 9.3 kPa (69.75 mmHg).

Pressure at the left greater trochanter

Figure 9: Relationship between BMI and left greater trochanter pressure – SAM Sling®.

Figure 10: Scatter plot demonstrating BMI and left greater trochanter pressure – SAM Sling®.

Figure 9 and 10 demonstrate the relation between BMI and the mean pressure exerted at left greater trochanter location. As depicted in figure 9, with higher BMI of the volunteers, the pressures exerted were higher and in volunteers with lower BMI, less pressure was exerted by the SAM Sling®. Figure 9 clearly depicts that in volunteers with higher BMI the pressure exerted on left greater trochanter was more than the tissue damaging pressure of 9.3 kPa (69.75 mmHg).

Figure 11: Comparison of pressure exerted by SAM Sling® on right and left sides.

As seen in figure 11, seeming observation is that measurements using the SAM-Sling® structurally produced higher mean pressures on the left location as compared to the right location. The likely explanation to this may be that SAM-Sling® has two straps which need to be pulled together with two hands in opposite directions and therefore the left side is exposed to higher force than the right side.

Pressure at the sacral location

Figure 12: Relationship between BMI and sacral pressure – SAM Sling®.

Figure 13: Scatter plot demonstrating BMI and sacral pressure – SAM Sling®.

Figure 12 and 13 demonstrate the relation between BMI and the mean pressure exerted at the sacral location. As depicted in figure 12, with higher BMI of the volunteers, the pressures exerted were higher and in volunteers with lower BMI, less pressure was exerted by the SAM Sling®. Figure 12 clearly depicts that the pressure exerted on sacral location was always more than the tissue damaging pressure of 9.3 kPa (69.75 mmHg) in all the volunteers. Hence it can be concluded from the findings that the sacral location is at higher risk of developing a pressure sore in comparison to other locations.

No.	BMI (kg/m ²)	Anterior (mmHg)	Rt. Greater Trochanter (mmHg)	Lt. Greater Trochanter (mmHg)	Sacral (mmHg)
1	20.2	18.66	78.66	76	78
2	29.3	24.66	88.66	79.33	108.66
3	31.9	32	94	88	126.66
4	27.89	33.33	76	72.66	123.33
5	31.96	32	102.66	95.33	136.66
6	25.4	26.66	83.33	75.33	123.33
7	22.3	26	74	71.33	115.33
8	25.8	28	75.33	73.33	125.33
9	21.2	18	55.33	60.66	102

Table 14: Mean pressure reading – T-POD®. BMI: Body Mass Index; Rt: Right; Lt: Left.

T-POD®

The average exerted pressure on the anterior location was 26.59 mmHg (3.54 kPa), on the right greater trochanter it was 80.88 mmHg (10.78 kPa), on the left greater trochanter it was 76.88 mmHg (8.45 kPa) and on the sacral it was 115.47 mmHg (15.39 kPa).

Pressure at the anterior location

Figure 14: Relationship between BMI and anterior pressure.

Figure 15: Scatter plot demonstrating BMI and anterior pressure – T-POD®.

Figure 14 and 15 demonstrate the relation between BMI and the mean pressure exerted at the anterior location. As depicted in figure 14, with higher BMI of the volunteers, the pressures exerted were higher and in volunteers with lower BMI, less pressure was exerted by T-POD®. It can be concluded from figures 14 and 4.12 that the pressure exerted on the anterior location were less than tissue damaging pressure of 9.6 kPa (69.75 mmHg).

Pressure at the rt. greater trochanter location

Figures 16 and 17 demonstrate the relation between BMI and the mean pressure exerted at right greater trochanter location. As depicted in figure 16, with higher BMI of the volunteers, the pressures exerted were higher and in volunteers with lower BMI, less pressure was exerted by the T-POD®. Figure 16 clearly depicts that in volunteers with higher BMI the pressure exerted on right greater trochanter was more than the tissue damaging pressure of 9.3 kPa (69.75 mmHg).

Pressure at the left greater trochanter location

Figure 18 and 19 demonstrate the relation between BMI and the mean pressure exerted at left greater trochanter location. As depicted in figure 18, with higher BMI of the volunteers, the pressures exerted were higher and in volunteers with lower BMI, less pressure was exerted by the T-POD®. Figure 18 clearly depicts that in volunteers with higher BMI the pressure exerted on left greater trochanter was more than the tissue damaging pressure of 9.3 kPa (69.75 mmHg).

As seen in figure 20, seeming observation is that measurements using the T-POD® structurally produced higher mean pressures on the right location as compared to the left location. The T-POD® mechanical pulley design allows it to be pulled in opposite directions thereby accounting for slightly higher right mean pressures.

Pressure at the sacral location

Figure 22: Scatter plot demonstrating BMI and sacral pressure – T-POD®.

Figure 21 and 22 demonstrate the relation between BMI and the mean pressure exerted at sacral location. As depicted in figure 21, with higher BMI of the volunteers, the pressures exerted were higher and in volunteers with lower BMI, less pressure was exerted by the T-POD®. Figure 21 clearly depicts that the pressure exerted on the sacral location was always more than the tissue damaging pressure of 9.3 kPa (69.75 mmHg) in all the volunteers. Hence it can be concluded from the findings that the sacral location is at higher risk of developing a pressure sore in comparison to other locations.

Figure 23: Pressures exerted by SAM Sling.

Figure 24: Pressures exerted by SAM Sling®.

Both types of pelvic binder exhibited different pressure characteristics as seen in figures 23 and 24.

Average mean pressure at anterior location was more for T-POD® which can be due to the fastener strings. Average mean pressure at right greater trochanter was more for T-POD® and at left greater trochanter was more for SAM Sling®, which can be attributed to the different closing mechanisms of both types of binder. Average mean pressure at sacral region was high for both SAM Sling® and T-POD®.

Discussion

Pelvic fractures are termed “Killing fractures” because they not only pose a threat to limb but are life threatening too [15]. Timely intervention helps in reduction of pelvic volume and stabilisation of fracture thereby achieving hemostasis and hence a decrease in mortality and morbidity associated with pelvic fractures. In recent years PCCD are the non-invasive method of choice for early fracture stabilisation. These devices can be easily applied by non-medical personnel at the accident site and hence are very appropriate for early phase of resuscitation especially within the “first hour” [2]. However, if PCCD are left on the patient for extended duration, the compressive pressure due to the device may jeopardise the underlying skin and lead to pressure sore.

The objective of the present research was to calculate the pressure exerted by pelvic binders and hence gain insight into the risk of developing skin necrosis due to the high pressure at four locations. Based on previous studies and literature data available the two most commonly used PCCDs were selected for the study. On extended application of PCCD, the risk of skin complications can be anticipated if the pressure applied surpasses 9.3kPa. The finding that the three pressure readings at all four locations were most alike for the T-POD® and SAM Sling® suggest that reproducibility of the measurements.

Figure 25: Comparison anterior pressure SAM Sling® v/s anterior pressure T-POD®.

In comparison with other locations, anterior mean pressure measurement was challenging. Figure 25 depicts the comparative data of SAM Sling® and T-POD® which suggests that the mean pres-

sures at anterior location were higher with SAM Sling® which can be attributed to the auto-stop buckle.

Figure 26: Comparison Rt. greater trochanter pressure SAM Sling v/s Rt. greater trochanter pressure T-POD®.

Figure 27: Comparison left greater trochanter pressure SAM Sling® v/s left greater trochanter pressure T-POD®.

As shown in Figures 26 and 27, SAM Sling® mean pressure readings were lowest at anterior and left greater trochanter and for T-POD® mean pressure readings were lowest at anterior and right greater trochanter. The differences can be attributed to the closing mechanisms. SAM Sling® closing mechanism consists of Velcro-belt which is supposed to be pulled through the auto-stop buckle while giving counter pull through the other strap. While doing so the pulling force is initially transmitted to the left location and hence this may be the reason for higher mean pressures exerted at the left side in comparison to the right side. However, the tab of T-POD® is pulled in an opposite direction towards the right side which leads to higher mean pressures on the right side in comparison to left side.

Figure 28: Comparison sacral pressure SAM Sling® v/s sacral pressure T-POD®.

Figure 28 shows mean pressures exerted on the sacral location were higher for both SAM Sling® and T-POD® and this is because the total pressure exerted at sacral region will be a combination of body weight and the pressure exerted by the PCCD.

In the current study, BMI had a direct correlation with mean pressure. The higher the BMI, the greater the mean pressure exerted by both SAM Sling® and T-POD® at all four locations. This is in contrast with the study by Jowett and Bowyer (2007), that demonstrated an inverse relation between BMI and pressures.

This current study had a few limitations. First, the chief investigator could not be blinded about the research. Secondly, this is a small study and no strong inferences about the risk for pressure sore can be concluded from the findings, and therefore the results should be established through a randomised control trial. Thirdly the pressure cuffs used were manual and each time they had to be calibrated manually which may have caused some error in readings [16-28].

Conclusion

This pilot study was conducted on healthy volunteers using two PCCDs and the results reflected mean pressures at four locations. For both SAM Sling® and T-POD®, anterior pressure was less than the tissue damaging level (9.3 kPa). Left and right greater trochanter pressures were close to the tissue damaging pressure level and the sacral pressures were higher than the tissue damaging pressures. Type of PCCD used, BMI and WC were the factors which affected the pressure exerted. When deducing the results to a clinical scenario, the binders may cause a risk of developing pressure sores.

However, this is a very small study and more research is needed in this subject.

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