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Original article

The effectiveness of modified seton and modified combat gauze in controlling severe hemorrhaging during operations of uniformed services

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Abstract

Hemorrhaging from large vessels poses a serious problem in emergency situations when blood loss needs to be immediately controlled. The aim of the study was to compare the effectiveness of two hemostatic dressings in controlling bleeding from a surgically punctured femoral artery. The study was performed on thirteen pigs divided into two groups, of six and seven pigs, respectively. Combat gauze covered with ChitoClear hqg 95 chitosan and Protanal LF10/60 FT sodium alginate was used in the first group, seton covered with identical substances was uses in the second group. Selected hemostatic dressing was applied to the wound 20 seconds after incision and then removed at regular time intervals to evaluate hemostasis. Modified seton was characterized by a shorter time to hemostasis than combat gauze. The result of this experiment indicate that modified seton proved to be a more effective dressing than modified combat gauze.

Key words: hemorrhage, hemostatic dressing, combat gauze, pig

Introduction

Hemorrhaging, in particular severe bleeding from large vessels, requires immediate medical attention due to a high risk of mortality (Jastrzębski et al. 2014). Wounds of that type are often encountered during operations of the uniformed services who perform their duties in health- and life-threatening situations (Cox et al. 2009) . The most common type of injuries in the special services are gun-shot wounds, followed by incisions and stab wounds. The extent and depth of the wound is determined by the type and severity of an injury as well as the part of the body exposed to damaging effects of a bullet, ricochet, shrapnel or a sharp tool. Traffic accidents and surgical interventions may also lead to hemorrhaging. Hemostatic dressings are effective in controlling profuse bleeding (Shina et al. 2015). They are used to suppress external

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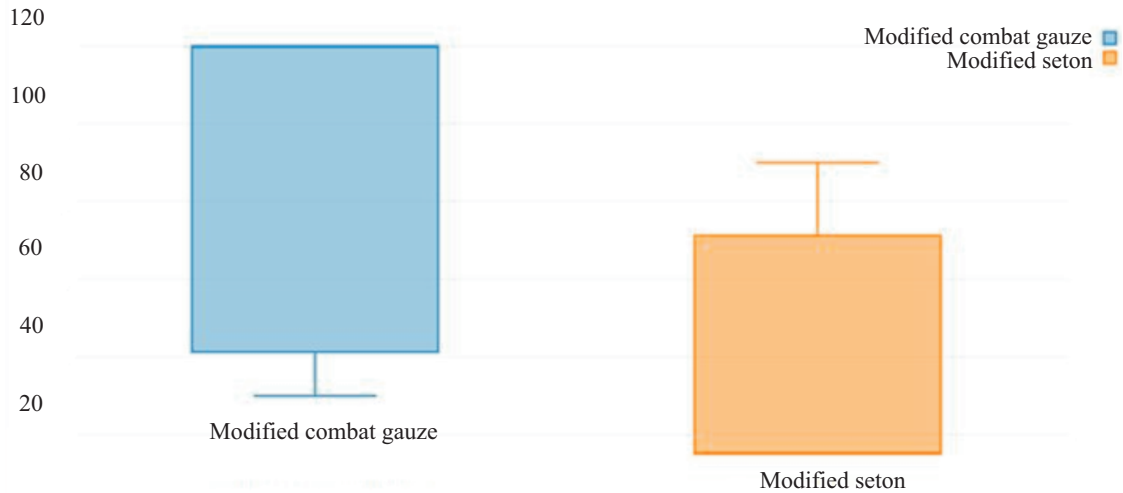

Fig. 1. The diagram shows time (min.) of effective hemostasis for two hemostatic dressings – modified combat gauze and modified seton.

hemorrhage that is not amenable to other bleeding control methods, including direct pressure applied to vessels, compression dressings and compression bands (Devlin et al. 2011). Hemostatic dressings are coated with substances that initiate clot formation in the wound site (Schwartz et al. 2011). The objective of this study was to evaluate the effectiveness of two dressing materials in controlling hemorrhaging from the femoral artery in pigs – seton and combat gauze coated with a substance that initiates local hemostasis.

Materials and Methods

The study was approved by the Institute for Animal Welfare and the Bioethics Committee. All animals were handled humanely in compliance with the Policy on the Humane Care and Use of Laboratory Animals and the standards of the Polish Council on Animal Care. The study was also approved by the Local Committee for Animal Care in Olsztyn (Protocol 44/2014/N).

The experiment was performed on 13 Polish Large White female pigs with body weight of 45 kg. The animals were divided into two groups of six and seven pigs, respectively. They were premedicated with atropine (Atropinum Sulfuricum) at 0.05 mg/kg BW IM, and azaperone (Stresnil) at 2.5 mg/kg BW IM. General anesthesia was induced with ketamine (Bioketan) at 8 mg/kg BW IM and maintained with propofol (Scanofol) at 10 mg BW IV. Additionally butorphanol (Butomidor) was administered as the analgesic drug at 0.2 mg/kg BW IV. Tracheal intubation with normoventilation was performed. Ringer's lactate solution was administered during surgery. Surgical procedures were identical in both groups. The operative field in the region of the left inguinal fossa was prepared, and a lateral incision was made across the femoral artery. The selected hemostatic dressing was applied to the wound 20 seconds after incision. Combat gauze covered with ChitoClear hqg 95 chitosan and Protanal LF10/60 FT sodium alginate (Institute for Synthetic Fiber Research in Łódź) was used in the first group. Seton covered with identical substances was applied in the second group. Blood pressure was monitored throughout the procedure. The hemostatic dressing was removed from the incision site at regular time intervals to evaluate hemostasis (Tables 1 and 2). The animals were transported to the post-operative recovery room after bleeding had stopped.

Results

Hemostasis was achieved in the group of animals where bleeding was controlled with modified seton (Table 2). Modified combat gauze was less effective in promoting adequate hemostasis. In this group of animals, hemorrhaging was stopped 45-120 minutes after the dressing had been applied to the wound and compressed manually in the site of incision (Table 1). The results were processed statistically by the Mann-Whitney U test to produce $Z = -2.1112$ and $p = 0.03486$. The result was statistically significant at $p \leq 0.05$, therefore, the null hypothesis postulating that time to effective hemostasis was identical for both dressings was rejected. The results of the test clearly indicate that modified seton was characterized by a shorter time to hemostasis than combat gauze.

The results are presented in a box plot: Min – Q1 (lower quartile) – Me (median) – Q3 (upper quartile) – Max. (Fig. 1) Time to effective hemostasis was much shorter for modified seton.

Table 1. The effectiveness of modified combat gauze in controlling hemorrhage.

Animal	Time of application after incision	Bleeding control	Bleeding control	Bleeding control	Bleeding control	Bleeding control	Remarks
Pig No. 1	20 seconds	15 minutes after application – bleeding	30 minutes after application – bleeding				Death 40 minutes after incision
Pig No. 2	20 seconds	15 minutes after application – bleeding	45 minutes after application – bleeding	60 minutes after application – bleeding	120 minutes after application – effective hemostasis		
Pig No. 3	20 seconds	15 minutes after application – bleeding	30 minutes after application – bleeding	90 minutes after application – effective hemostasis			
Pig No. 4	20 seconds	15 minutes after application – bleeding	30 minutes after application – bleeding	60 minutes after application – bleeding	90 minutes after application – bleeding	120 minutes after application – effective hemostasis	
Pig No. 5	20 seconds	15 minutes after application – bleeding	30 minutes after application – bleeding	45 minutes after application – effective hemostasis			
Pig No. 6	20 seconds	15 minutes after application – bleeding	30 minutes after application – bleeding	60 minutes after application – bleeding	120 minutes after application – bleeding		Blood vessels were closed surgically

Discussion

The analyzed dressings were seton and combat gauze which were coated with blood clotting compounds: ChitoClear hqg95 chitosan and Protanal LF10/60 FT sodium alginate. Chitosan is the active ingredient, and its mucoadhesive function is independent of the coagulation cascade (Satterly et al. 2013). In a number of case studies, chitosan dressings were effectively used to stop bleeding in patients with life-threatening hemorrhage and severe coagulopathy (Gegel et al. 2013). Chitosan can be also safely used in persons allergic to shellfish (Waibel et al. 2011). Combat Gauze, Celox Gauze and ChitoGauze are the most popular hemostatic dressings (Schwartz et al. 2011) which are recommended by the US Committee on Tactical Combat Casualty Care (CoTCCC-Recommended Hemostatic Agents) (Rall et al. 2013) as the first choice for hemostatic dressing. The analyzed dressing materials have been found to be safe and effective in hemorrhage control (Granville-Chapm an et al. 2011). In previous experiment segmental damage to muscle tissue was noted on account of direct contact with the dressings (ChitoGauze and Celox Gauze) for 24 hours (Adamiak et al. 2014). Combat Gauze effectively stops bleeding (Satterly et al.2013), and safety issues have never been reported in respect of this dressing material. Combat Gauze is a 3-inch x 4-yard roll of sterile gauze impregnated with kaolin, a substance that induces blood clotting (Watters et al. 2011). In our study combat gauze used was composed of 17-thread sterile gauze and seton comprised of 17-thread 4-ply cotton gauze. In all cases in the combat gauze group time of effective hemostasis was longer than 30 minutes and in one case blood vessels were closed surgically. In the seton group the applied dressings effectively controlled bleeding from the femoral artery in all patients and none of them died during the experiment. In five cases required time for hemostasis didn't exceed fifteen minutes. Seton demonstrated a greater degree of efficacy than combat gauze. The availability of effective hemostatic dressings should not preclude further search for other materials that can be coated with

Table 2. The effectiveness of modified seton in controlling hemorrhage.

Animal	Time of application after incision	Bleeding control	Bleeding control	Bleeding control	Bleeding control	Remarks
Pig No. 1	20 seconds	15 minutes after application – effective hemostasis				
Pig No. 2	20 seconds	15 minutes after application – bleeding	45 minutes after application – bleeding	60 minutes after application – bleeding	90 minutes after application – effective hemostasis	
Pig No. 3	20 seconds	15 minutes after application – effective hemostasis				
Pig No. 4	20 seconds	15 minutes after application – effective hemostasis				
Pig No. 5	20 seconds	15 minutes after application – effective hemostasis				
Pig No. 6	20 seconds	15 minutes after application – bleeding	45 minutes after application – bleeding	60 minutes after application – bleeding	90 minutes after application – effective hemostasis	
Pig No. 7	20 seconds	15 minutes after application – bleeding				

chemical substances to induce rapid hemostasis. The above assumption was made in this study. The results of this study can be used to design new hemostatic dressings based on seton.

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