Comparison of hemostatic efficacy of Axiostat gauze and combat gauze in swine arterial hemorrhage model

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Abstract

Hemorrhage from the splanchnic and the junctional regions is the leading cause of preventable deaths in the battlefield. An ideal hemostatic agent for the battlefield and prehospital hemorrhage control should have the characteristics like quick and effective, easy administration, easy removal, low cost, prolonged stability, and good biocompatibility with no adverse effects. Chitosan has many applications in the medical field including the application as a topical hemostatic agent. The wide usage of chitosan as a hemostatic agent makes it the material of choice for hemostasis. The objective of the present study was to compare the 100% chitosan-based Axiostat gauze (AG) with combat gauze (CG) and understand the efficacy of these in a swine arterial hemorrhagic model. The total blood loss during the surgery was lower in AG when compared to CG. As the AG hemostatic gauze prepared with chitosan was equally efficient in comparison to CG we recommend the use of AG for severe bleeding in the military as well as civilian settings in prehospital care.

Introduction

Increasing demand for efficient and cost-effective hemostatic agents has led to the exploration of chitosan as a viable solution. Derived from chitin, chitosan exhibits exceptional hemostatic properties, making it an attractive option for controlling bleeding. Its biocompatibility and biodegradability have been extensively investigated, ensuring its safety and compatibility within the human body. Consequently, chitosan has become the material of choice for hemostatic applications, playing a significant role in enhancing patient care and improving clinical outcomes. The objective of the present study was to compare a 100% chitosan-based gauze, Axiostat gauze (AG) with combat gauze (CG) and understand the efficacy of these in a swine arterial hemorrhagic model.

Methodology

- Before the surgery date, venous blood samples were collected for the complete blood count and standard clotting tests were performed to ensure that these parameters were within the normal range and met the inclusion criteria .
- The right carotid artery was cannulated for withdrawal of the blood and was used for continuous recording of blood pressure and heart rate throughout the experiment. The right jugular vein was catheterized (8.5/9 Fr catheter) for administering resuscitation fluid during hemorrhage and before achieving hemostasis.
- An incision of 10 cm was made on the skin in the groin area parallel and close to the femoral artery, the femoral artery was isolated by excising the muscles that directly covered the artery. A 5 cm section of the artery was dissected free from the surrounding tissues with cauterization and ligation (using 7–0 Proline) of small arterial branches.
- Free bleeding was allowed for 45 seconds. The shed blood was collected by suction, weighed, and recorded as pretreatment blood loss. (Kheirabadi, 2011).

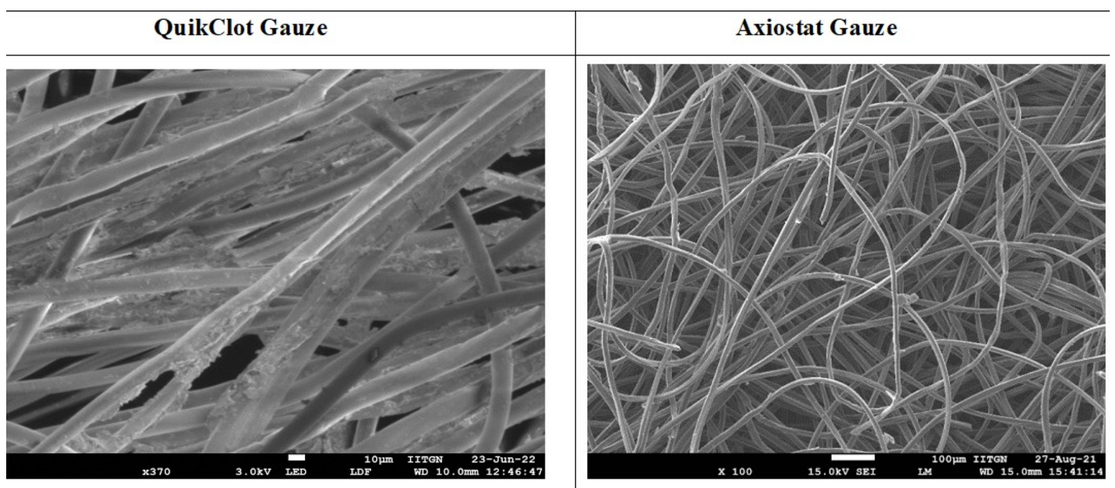

Figure 1. Under the scanning electron microscope, the morphology of both AG and CG dressings were analyzed. In dry conditions, the kaolin particles were found on the surface of the CG but no particles observed in AG.

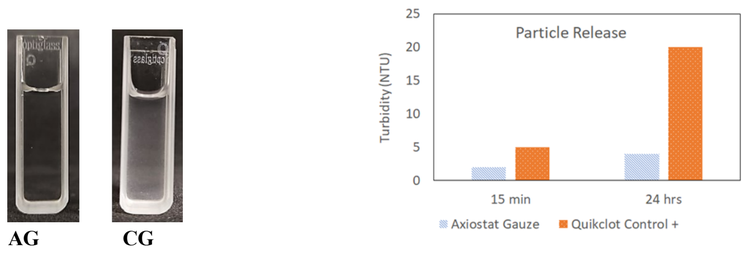

Figure 3. Visual and turbidimetry analysis

Results and Discussion

Hemodynamic and hematological parameters of the swine before experimentation

Parameter	AG	CG	p value
Body weight (kg)	41.1 ± 1.03	40.4 ± 1.0	0.78
Temperature (°C)	37.5 ± 0.18	37.7 ± 0.26	0.55
Mean Arterial Pressure (MAP) (mmHg)	78.1 ± 0.88	79.8 ± 2.41	0.55
Hemoglobin (g/dL)	9.4 ± 0.06	9.5 ± 0.06	0.17
Platelets (1,000/µL)	458.3 ± 30.18	436.0 ± 15.57	0.54
Prothrombin time (PT) (s)	11.9 ± 0.7	12.4 ± 0.95	0.69
Activated Partial Prothromboplastin time (aPTT) (s)	15.3 ± 0.42	14.9 ± 0.87	0.72
Fibrinogen (mg/dL)	258.3 ± 9.39	252.7 ± 6.01	0.61
pH	7.4 ± 0.01	7.4 ± 0.02	0.81

Hemodynamic and hematological parameters of the swine after experimentation

Parameter	AG	CG	p value
Temperature (°C)	38.1 ± 0.22	38.1 ± 0.26	0.77
Mean Arterial Pressure (MAP) (mmHg)	63.5 ± 1.79	67.1 ± 1.7	0.29
Hemoglobin (g/dL)	8.0 ± 0.23	7.6 ± 0.18	0.20
Platelets (1,000/µL)	273.0 ± 34.02	236 ± 16.09	0.38
Prothrombin time (PT) (s)	11.3 ± 0.4	11.4 ± 0.37	0.87
Activated Partial Prothromboplastin time (aPTT) (s)	15.5 ± 0.36	15 ± 0.97	0.62
Fibrinogen (mg/dL)	222.1 ± 5.77	213.7 ± 3.71	0.30
pH	7.4 ± 0.01	7.4 ± 0.03	0.42

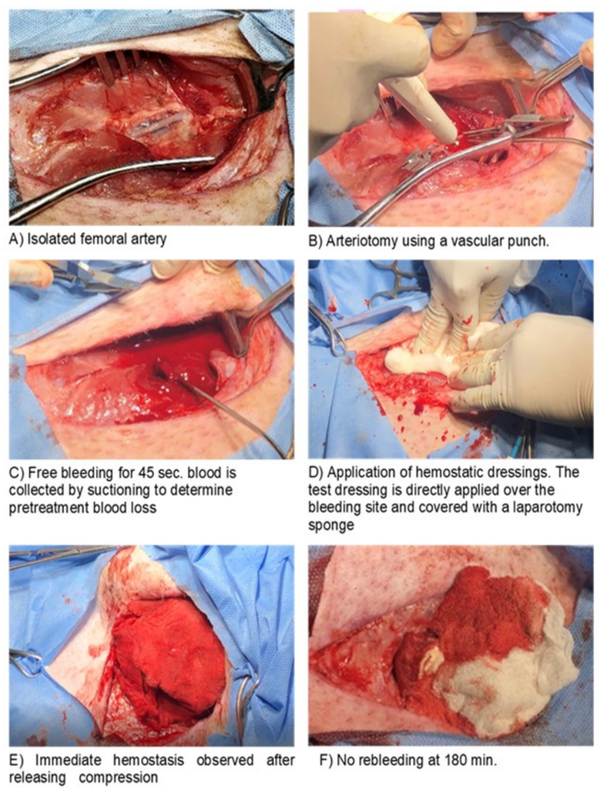

Figure 6. The procedure followed during the experiment

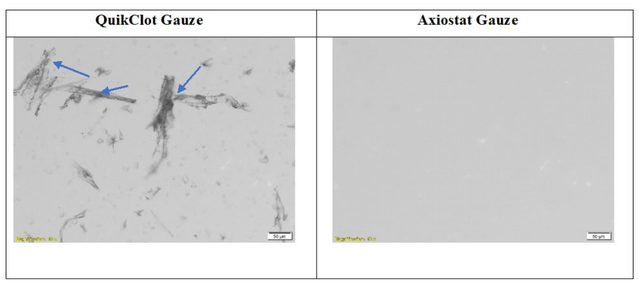

Figure 4. Microscopic images of AG extract and CG extract

- Visual observations including free dispersed particles of product were noted.
- Turbidimetry shows that Axiostat has no particles in the extract, whereas CG has higher turbidity over the period, indicating that it releases particles (Figure 1-4).

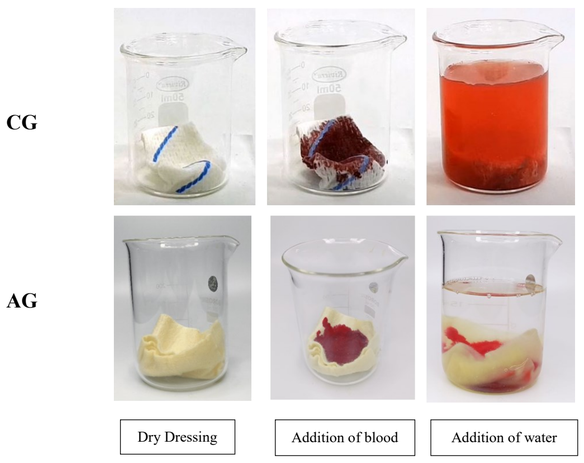

Figure 5. In vitro, blood clotting test showed Axiostat gauze strongly clots the blood in comparison with CG.

Hemostasis parameters in swine

Outcome	AG	CG
Pre-treatment blood loss (mL/kg)	16.3 ± 1.29	17.5 ± 1.24
Post-treatment blood loss (mL/kg)	7.1 ± 1.1*	36.2 ± 3.1
Total blood loss (mL)	966 ± 118*	2198 ± 149
Immediate hemostasis Achieved	2/3	0/3
Eventual hemostasis Achieved	3/3	3/3
Number of dressings used	1 per animal	1 per animal
Rebleeding after simulated walking action	2/3	3/3
Survival rate	3/3	1/3
Survival time	>180 min	130 ± 26.46

Conclusion

In vitro characterization of the developed AG suggests that the gauze can be an efficient hemostat and fluid absorber. The AG and CG groups showed a similar hemostatic effect in an extremity arterial hemorrhage model in swine. (Figure 5) . Although AG exhibited quicker hemostasis in some of the animals, overall hemostatic efficacy of both products was comparable (Figure 6). The hemostatic mechanism of AG is based on its physical attachment/adhesion to the injured tissues that is mediated by formation of clots at the interface.

In conclusion, the AG is an effective hemostatic dressing for the management of severe traumatic bleeding where tourniquet application is not feasible or can be used along with the tourniquet.

Reference

Kheirabadi, B. (2011). Evaluation of topical hemostatic agents for combat wound treatment. In *U.S. Army Medical Department journal*.