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*Original article*

# Comparison of conventional methods with commercially available topical hemostat surgical snow (oxidized cellulose) for achieving hemostasis in canine model of partial splenectomy

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## Abstract

Spleen is highly vascularized organ and bleeding control during partial splenectomy is a big challenge. In this study conventional methods of electrocautery, absorbable suturing and advance methods of topical hemostat Surgicel® were compared to control bleeding during partial splenectomy. Twelve healthy dogs (n=4) were divided in A, B and C groups. After partial splenectomy Surgicel®, electrocautery and absorbable horizontal mattress sutures were used to control hemorrhages in group A, B and C respectively. Bleeding time and loss of blood volume was evaluated during surgery. In addition, blood samples were taken on day 0 pre-surgery and on days 3, 10 and 17 post-surgery to evaluate changes in biochemical parameters after the application of different hemostatic techniques. Ultrasonography was also performed at alternative days to check any gross changes in the spleen. Dogs in group A showed minimum bleeding time and loss of blood volume as compared to group B and C. Drop in red blood cells count was compared between group A, B and C showing significant change ($p \leq 0.05$) at day 3, 10 and 17, while a significant decline in hemoglobin was found in group C followed by groups B and A at 3rd and 10th day. There was no difference between platelet counts in various groups. Ultrasonography showed no significant changes in the spleen parenchyma. It was concluded that Surgicel® was an effective material for controlling hemorrhage in veterinary patients.

**Key words:** bleeding time, dogs, electrocautery, hematobiochemical parameters, partial splenectomy, Surgicel®

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## Introduction

During surgical interventions control of bleeding is the most crucial step followed by establishment of sufficient ventilation by securing air ways (Plaisier 2001). In an accident, hemorrhage is the leading cause of death (30.5%) after head injury (Shackford 1995). Indications for the partial splenectomy include diagnostic idiopathic splenomegaly, splenic infarct, benign splenic tumors, metastases, splenic cysts, iatrogenic splenic injury, and the hematologic disorder inherited spherocytosis. Partial splenectomy may decrease hemolytic problems such as anemia, gallstones, and exercise intolerance while preserving splenic function (Hassoun et al. 2018). Spleen receives blood approximately 300ml/min or more than 5% of the cardiac output, that is why spleen is called highly vascularized organ. In this way chances of bleeding are high during partial splenectomy (Chadburn 2000).

The hemostasis can be achieved by different methods, like manual pressure application and electrical tissue cauterization or topical application of coagulation agents. Topical agents can also be used for hemostasis in addition to pressure application, vessel ligation, or electrocautery (Sileshi et al. 2008). Surgicel® (Oxidized Regenerated Cellulose) is a sterile bioabsorbable topical hemostat (Arnold and Sodickson 2008), thrombogenic in nature (Turley et al. 1994, Insert 2005) used in various surgical procedures during uncontrolled bleeding. The mechanism of action (MOA) of oxidized cellulose is involved in lowering the pH of bleeding site which results in hemolysis followed by oxidization of hemoglobin (Sileshi et al. 2008). Therefore, the aim of the study was to compare the efficacy of Surgicel® and other conventional hemostatic methods used during surgical interventions.

## Materials and Methods

### Material

Surgicel® (oxidized regenerated cellulose) is a sterile knitted fabric, due to its unique physical properties of thrombus formation, it is frequently used as effective agent in intra operative hemostasis. It is a bioabsorbable material and can be left in the surgical bed. Vicryl (polyglactin 910) suture material is a bio absorbable and synthetic material is used for ligation of blood vessels and soft tissue approximation. Electrocautery is also called thermal cautery in which direct or indirect current passes through a resistance metal wire electrode, which generate the heat. The heated probe is applied to living tissue to achieve hemostasis or varying degree of tissue destruction.

### Methods

This experimental study was done in twelve adult dogs having weight ranged 10-15 kg were presented at surgery clinic for complaint of splenic disorders. The animal patients were admitted at the surgery section kennels of the University of Veterinary and Animal Sciences- Lahore. All necessary arrangements were made regarding proper preoperative assessments, feeding ad libitum watering and careful monitoring of parameters for the animal patients.

All the procedures were conducted according to the rules and regulations approved by the Ethical Review Committee (ERCULA), and Department of Clinical Medicine, University of Veterinary and Animal Sciences Lahore (Pakistan).

Dogs were divided into three groups named as A, B, and C (n=4). In all the groups partial splenectomy was performed. In group A, surgicel®, in group B, electrocautery and in group C, absorbable hemostatic suture were used to control bleeding. Dogs were fastened for 12 hours before the surgery. On surgical day 0 and post-surgical days 3, 10, and 17, blood samples were collected from the cephalic vein for complete to blood counts including white blood cells, red blood cells, hemoglobin and platelets.

The surgeries were performed under the general anesthesia. Fifteen minutes before the surgery, pre-anesthetic agent Atropine sulphate at a dose of 0.04 mg/kg was injected subcutaneously. In Groups A, B and C general anesthesia was maintained with a cocktail of 5% ketamine and 2% xylazine at a dose of 5.5 mg/kg and 1.1mg/kg through intravenous route respectively (Franco et al. 2009).

The surgical site was clipped and disinfected with povidone iodine and alcohol. The spleen was recognized and exteriorized from the laparotomy incision. Adequate mobilization of the spleen was achieved by ligation of short gastric vessels and dissecting the gastrosplenic ligament. The splenic vessels which supplied the upper pole were ligated and dissected which resulted in the alternation in the color of the upper pole. The parenchymal sectioning line was determined on the transition zone between the normal and ischemic parenchyma and partial splenectomy was performed.

In group A, after performing partial splenectomy, the resected site was covered with Surgicel®, later on it was covered with dry gauze and occlusive digital pressure was applied for 30 seconds to 1 minute. Digital pressure was withdrawn to check whether hemostasis was achieved or not within 30 sec. In case of failure of hemostasis within 30 seconds, again Surgicel® snow was applied over the area to control the bleeding, followed by new dry gauze and additional digital pressure

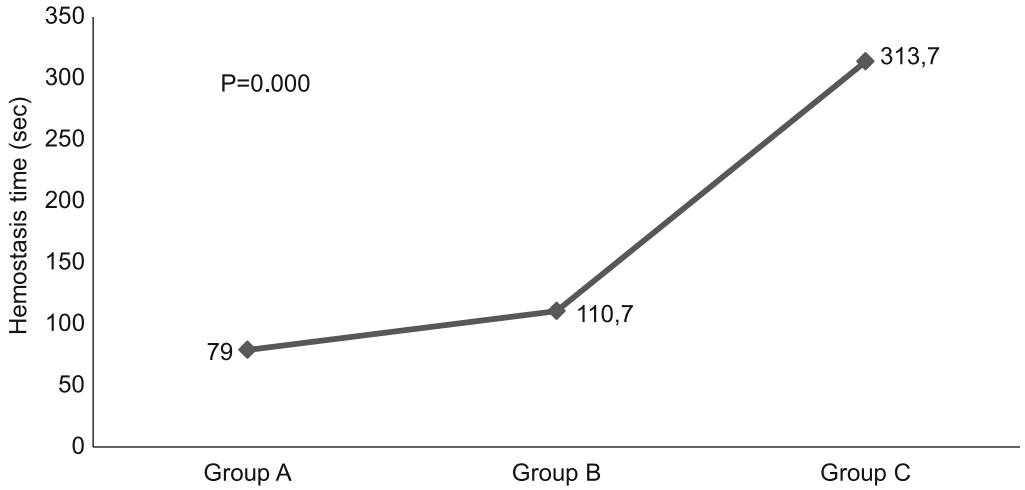


Fig. 1. Mean value of hemostasis time of Group A, B and C dogs treated with Surgicel Snow, Cautery and Absorbable Suture respectively.

for 30 seconds to 1 minute. After hemostasis was achieved finally, the readings were recorded for total time of hemostasis.

In group B, partial splenectomy was performed, and hemostasis was achieved through electrocautery. The blood vessels were cauterized to stop bleeding. To stop bleeding, dry gauze was applied over sectioned surface alongwith digital pressure for 30 seconds to 1 minute. After 30 seconds, gauze was removed to evaluate the hemostasis. If hemostasis was achieved within 30 seconds, the readings were recorded for total time of hemostasis. In case of bleeding, again cauterization of small bleeders was performed and same procedure was repeated to calculate the hemostasis time.

In group C, the same procedure is followed for partial splenectomy as in group A but hemostasis was achieved through absorbable horizontal mattress sutures surgical vicryl number 2-0. The sutures were applied over the sectioned area of spleen. Evaluation of hemostasis was assessed similarly as in group A and B. If hemostasis was achieved within 30 seconds, time to hemostasis was noted. Finally, the splenic capsule was sutured in inverted suture pattern with the help of absorbable suture material surgical vicryl 2-0 to avoid adhesion of sectioned area of spleen with other abdominal tissues.

Loss of blood volume was calculated in all groups A, B and C by weighing the blood packed gauzes and subtracting the weight of the dry gauzes.

In all the groups, laparotomy incision was closed after surgery using three layers closure technique.

### Statistical analysis

Results were analyzed by using software SPSS version 20.0 and One-way ANOVA with significant level 0.05% ($p<0.05$).

## Results

### Haemostasis time

Mean hemostasis time of group A was 79, B 110.7 and in C was 313.7 seconds as shown in (Fig 1). Dogs in group A showed minimum hemostasis time as compared to electrocautery and absorbable suture group.

### Loss of blood volume

Blood loss after application of Surgicel® (10.22 g) was significantly lower than electrocautery (18.80 g), absorbable suture (39.47 g) ($p=0.000$) as shown in (Fig. 2). Results showed that in group A loss of blood was minimum as compared to B and C.

### Changes in laboratory parameter after partial splenectomy

Total number of white blood cells and platelets in groups A, B, and C before (day 0) and after surgery at day 3, 10, and 17, showed non-significant results among three groups ($p>0.05$). Changes in red blood cells exhibit significant difference ($p<0.05$) at day 3 , 10 and 17 among groups A, B and C. Pre surgical, count of red blood cells expressed in mean and standard deviation in surgicel® (6.66±0.34), electrocautery (6.43±0.37) and absorbable suture was (6.62±0.43) showing non-significant $p>0.668$. At day 3, red blood cells number in Surgicel® group were (6.25±0.430), electrocautery (5.56±0.21) and absorbable suture (5.46±0.37) showing significant change ($p<0.022$), at day 10 red blood cell numbers in surgicel® group was (6.04±0.37), electrocautery (5.65±0.12) and in absorbable suture group (5.51±0.17) were significantly different $p<0.035$; and at day 17 Surgicel® (6.39±0.21), electrocautery (6.08±0.18) and absorbable suture (5.95±0.17) showed

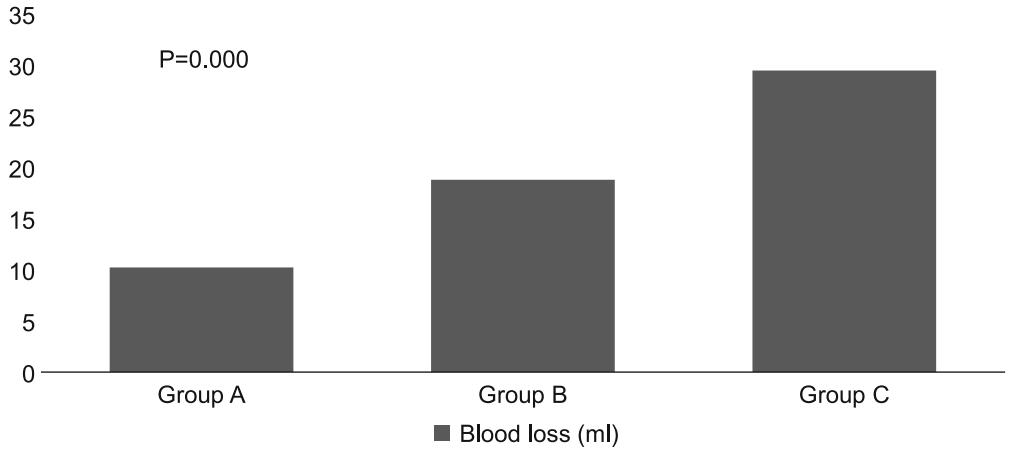


Fig. 2. Mean value of Blood loss of Group A, B and C treated with Surgicel Snow, Electrocautery and Absorbable Suture respectively.

Table 1. comparison of laboratory parameters before surgery at day 0 and after surgery, at 3rd, 10th, and 17th day.

| | | B.S day 0 | | A.S day 3 | | A.S day 10 | | A.S day 17 | |
|---|---|---|---|---|---|---|---|---|---|
| Parameters | Groups | Mean±SD | P-value (p<0.05) | Mean±SD | P-value (p<0.05) | Mean±SD | P-value (p<0.05) | Mean±SD | P-value (p<0.05) |
| WBC×$10^9$/l | A | 12.63±3.2 | | 26.18±3.2 | | 15.61±2.1 | | 12.65±0.9 | |
| | B | 11.35±2.1 | 0.668 | 27.33±2.2 | 0.662 | 19.82±3.2 | 0.151 | 13.12±2.3 | 0.462 |
| | C | 13.02±2.3 | | 28.12±3.7 | | 20.52±4.5 | | 14.60±2.8 | |
| RBC×$10^{12}$/l | A | 6.66±0.34 | | 6.25±0.43 | | 6.04±0.37 | | 6.39±0.21 | |
| | B | 6.43±0.37 | 0.668 | 5.56±0.21 | 0.022 | 5.65±0.12 | 0.035 | 6.08±0.18 | 0.028 |
| | C | 6.62±0.43 | | 5.46±0.37 | | 5.51±0.17 | | 5.95±0.17 | |
| Hb g/dl | A | 14.2±0.38 | | 13.3±0.20 | | 13.1±0.45 | | 13.5±0.54 | |
| | B | 14.4±0.71 | 0.910 | 12.5±0.75 | 0.005 | 12.5±0.15 | 0.006 | 13.1±0.29 | 0.228 |
| | C | 14.3±0.58 | | 11.4±0.70 | | 12.0±0.42 | | 12.9±0.65 | |
| PLT×$10^9$/l | A | 293±48 | | 456±33 | | 383±47 | | 330±44 | |
| | B | 263±42 | 0.612 | 532±53 | 0.085 | 457±50 | 0.268 | 385±22 | 0.256 |
| | C | 268±43 | | 529±52 | | 432±57 | | 384±71 | |

Group A: (surgicel); group B: (electrocautery); group C: (absorbable suture). WBC, white blood cells; RBC, red blood cells; Hb, heamoglobin; PLT, platelets concentrations.

significant change p<0.028. Post-surgical at day 3 and 10, hemoglobin concentration was showing significant difference (p<0.05) between group A, B, and C. At day 3, hemoglobin concentration, surgicel®, electrocautery, and absorbable suture were (13.3±0.20), (12.5±0.75), and (11.4±0.70) respectively p=0.005, and at day 10 (13.1±0.45), (12.5±0.15) and (12.0±0.42) p=0.006. On the basis of statistical values, group C showed maximum drop in hemoglobin concentration as compared to A and B group as shown in Table 1.

## Ultrasonography

There were no changes observed in spleen parenchyma after application of three different hemostatic techniques during partial splenectomy. Ultrasonography was performed at 7, 14 and 17 day to screen any post-surgical changes in spleen anatomy. The observations were described as under:

| Methods | Observations | Remarks |
|---|---|---|
| Surgicel® | Architecture and echogenicity | Hypoechoic, normal texture, sharp edge and grey colour |
| | Blood in abdomen | Not seen |
| | Acute splenitis | Not seen |
| | Splenomegaly | Not seen |
| Electrocautery | Architecture and echogenicity | Hypoechoic, normal texture, sharp edge and grey colour |
| | Blood in abdomen | Not seen |
| | Acute splenitis | Not seen |
| | Splenomegaly | Not seen |
| Absorbable suture | Architecture and echogenicity | Hypoechoic, normal texture, sharp edge and grey colour |
| | Blood in abdomen | Not seen |
| | Acute splenitis | Not seen |
| | Splenomegaly | Not seen |

## Discussion

Hemostasis within short time during surgery is beneficial for patient and surgeon and it is one of the important aspects of research (Shackford 1995). For control of bleeding different conventional methods have been used in past which were categorized as (sutures, ligature clips, electrocautery, argon beam laser) (Uranüs et al. 1996). Mean hemostasis time was reduced in surgicel treated group. Our study was in accordance with the Jukes et al. 2017, who reported that fibrin glue, patch and surgicel snow are potentially valuable adjuncts to control of major vessel hemorrhage. Surgicel is a topical thrombogenic hemostatic agent which helps to control hemorrhages of capillaries, veins and small arteries, when ligation or other conventional methods not able to control hemorrhages (Arnold and Sodickson 2008, Abbas et al. 2018).

Surgicel snow is effective hemostat as compared to cauterization and ligation with absorbable suture materials on splenic parenchyma. Similar findings were observed in a study conducted to check the efficacy of oxidized regenerated cellulose ORC on the parenchymal wedge resection of spleen and liver, loss of blood volume was minimum after appliance of oxidized regenerated cellulose ORC (Kim et al. 2017).

Post-surgically, the WBC's count was first increased in all groups, that increased may be due to transitory post-surgical infection or inflammation at surgical site. Transient elevations of the serum white blood white cell count are normal physiologic responses after splenectomy (Weng et al. 2005). At day 17, the values of WBCs were in normal range. None of the animal patient developed infection after splenectomy in our study. Our study was in accordance to Bessler et al. 2004, who reported that 70% of spleen in mice was found to be sufficient to maintain normal WBCs count.

Significant difference was found in RBCs between all groups. Due to high bleeding in group C, at day 3, mean concentration of RBCs was slightly decreased from normal range, at day 10 and 17, this mean concentration was observed within normal range but these mean RBCs values were less than preoperative mean RBCs concentration. When surgicel applied to the bleeding area, it swells in brownish/black gelatinous mass that aids in clotting process. Because this agent lowers the PH of surrounding tissues, red blood cell lysis occurs, which lowers the RBCs count temporarily. In a study RBCs counts of total splenectomy and partial splenectomy was compared, rabbits of total splenectomy and partial splenectomy produced an immediate decrease in RBCs counts. But in about a week the RBCs start to increase and in 4 to 8 weeks number of RBCs reached to pre-operative RBCs number Mole 1925.

Results of group A, B and C were shown significant difference in Hb concentration. Decreased in Hb concentration was within normal range in group A and B except in group C where Hb was dropped from normal range. A study was conducted on subtotal splenic resection with the help of cavitron ultrasonic surgical aspiration, in which hemoglobin and hematocrit values were evaluated between 1$^{st}$ and 10$^{th}$ post-operative day. In this study mean decrease in hemoglobin concentration 0.4 g/dl was recorded (Derderian et al. 1982).

Results of platelets showed that there was no significant difference found between A, B and C group at 3, 10 and 17 day. Increased in platelets count from normal range was recorded at day 3 in all groups A, B and C respectively. At day 10 and day 17, increased concentration of platelet was within normal range in all groups, but this concentration was increased from pre-operative platelets concentration. our study was in accordance to Atichartakarn (2003) who reported platelet hyperactivity in the patients who underwent splenectomy.

## Conclusions

On the basis of this experimental study surgicel snow is effective hemostat with minimum bleeding time and loss of blood volume as compare to convential hemostatic methods. Surgicel snow is absorbable topical hemostat having least effect on spleen and on haematological parameters. It is easy to apply and decrease surgical time.

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