

Sponge in the belly: postoperative imaging findings of oxidised cellulose (Surgicel®)

Arzu PAMPAL¹, Gökçe Kaan ATAÇ^{2*}, İbrahim Onur ÖZEN³, Zekiye Safinur KESKİN²,
Billur DEMİROĞULLARI³, Sadi GÜNDOĞDU²

¹Department of Paediatric Surgery, Faculty of Medicine, Ufuk University, Ankara, Turkey

²Department of Radiology, Faculty of Medicine, Ufuk University, Ankara, Turkey

³Department of Paediatric Surgery, Faculty of Medicine, Gazi University, Ankara, Turkey

Received: 26.06.2012 • Accepted: 12.09.2012 • Published Online: 29.07.2013 • Printed: 19.08.2013

Aim: Surgicel® is an absorbable material for local haemostasis. Its existence at surgical sites is troublesome since it interferes with the radiological images of postoperative complications. The aim of this study is to demonstrate the postoperative appearances of intraabdominal Surgicel.

Materials and methods: Twelve guinea pigs were allocated to 2 groups. Animals with intraperitoneal (n = 6) and retroperitoneal (n = 6) Surgicel pieces were scanned postoperatively.

Results: The density and intensity of Surgicel were compared with adjacent tissues. All retroperitoneal haemostats were hypointense compared to tissues next to them in T1W images but hyperintense compared to muscles, and 5 were hyperintense compared to the liver and hypointense compared to fat and the renal cortex in T2W images. All intraperitoneal haemostats were hypointense compared to the liver, fat, and renal cortex in T1W but hyperintense compared to muscles, the liver, and the renal cortex in T2W images. On CT scans, all retroperitoneal haemostats were hyperdense compared to fat tissue and 4 were hypodense compared to liver and muscles. All intraperitoneal haemostats were hypodense compared to muscles and the liver while 5 were isodense compared to fat and hypodense to the renal cortex.

Conclusion: Surgicel located intraabdominally could appear radiologically distinct. Considering the surgical site and anatomical spaces of Surgicel could help clinicians to evaluate the situation.

Key words: Computed tomography, magnetic resonance imaging, oxidised regenerated cellulose, postoperative images, Surgicel

1. Introduction

Surgicel Absorbable Haemostat® (Johnson & Johnson Medical Ltd., UK) is a sterile absorbable knitted fabric prepared by the controlled oxidation of regenerated cellulose. It is a surgical material used in order to obtain local haemostasis. When applied to the surgical area, it swells into a brown-black gelatinous mass, which aids in the formation of clot to control local haemorrhage.

Its usage in intraabdominal or retroperitoneal surgical procedures is somewhat troublesome to both surgeons and radiologists while evaluating the postoperative cross-sectional imaging of patients, as it generally interferes with early findings of postoperative complications like abscess, haematoma, or ongoing oozing (1–3).

There are limited data in the literature about the postoperative images of Surgicel by computed tomography (CT) and magnetic resonance imaging (MRI). The aim of this study is to demonstrate the postoperative appearances of absorbable haemostat located intraperitoneally and

retroperitoneally by consecutive CT and MRI scans. For this purpose, an experimental study was designed.

2. Material and methods

The study protocol was approved by the animal ethics committee (G.U.ET-10.119) and performed according to the guidelines of the Research Committee of the Faculty of Medicine at Gazi University. The study comprised 12 male guinea pigs weighing 490 g to 560 g (mean: 535 g). All animals were kept under controlled temperature (21 ± 2 °C) and humidity (55.5%) with a 14-h light and 10-h dark cycle. They were fed with commercial food and they had free access to water. There were no water and light restrictions throughout the experiment. All animals received humane care in compliance with the “Principles of Laboratory Animal Care” formulated by the National Society for Medical Research and the “Guide for the Care and Use of Laboratory Animals” prepared by the Institute of Laboratory Animal Resources published by

* Correspondence: gokcekaan_atac@yahoo.com

the National Institutes of Health. The same 2 surgeons in sterile conditions performed all surgical procedures. Every surgical intervention and radiological evaluation was performed under 50 mg kg⁻¹ ketamine hydrochloride (Ketalar, Eczacıbaşı, Turkey) and 5 mg kg⁻¹ xylazine hydrochloride (Alfazyne, Ege Vet, Turkey) anaesthesia.

Twelve male guinea pigs were divided into 2 groups consisting of 6 animals in each group. Each animal in either group was marked with a discrete tattoo on the ear before the surgical intervention in order to make sure to obtain consecutive scanning records of the same animal. In the intraperitoneal group, 6 animals underwent a midline laparotomy, and a piece of Surgicel (7 × 5 cm) was loosely sutured to the caudal part of left lobe of the liver with a 6/0 Vicryl suture. The midline incision was closed while the oozing from the liver was going on under the Vicryl stitch. In the retroperitoneal group, 6 animals were operated in lateral decubitus position through a right-side flank incision. After muscle splitting and dissection of the peritoneum away from the spinal muscles, the muscular layer was rubbed in order to create an oozing. A piece of Surgicel (7 × 5 cm) was placed in the retroperitoneal space and the flank incision was closed. It was planned for the animals in each group to be scanned with CT and MRI on the 1st, 4th, 7th, 10th, 14th, 21st, and 28th postoperative days. The animals were scanned one by one after being placed in supine position in cardboard boxes under sedation. CT and MRI scans were taken respectively for all animals without enteral/parenteral contrast material administration.

CT imaging was performed by a GE Light Speed 16-row multidetector scanner (GE Health Care USA). Continuous 0.6-mm-thick sections were produced and axially and coronally reformatted. Guinea pigs were located inside the quadrature knee coil with 4 channels. An AW4 workstation (GE Health Care) with 2 screens was used for both CT and MRI studies. Two radiologists evaluated all images separately.

Intraperitoneal and retroperitoneal Surgicel pieces were evaluated by comparing the densities and intensities of the haemostat with the paravertebral muscles, paravertebral fat tissue, the liver, and the cortical parenchyma of the kidney. Intensities of retroperitoneal Surgicel pieces were compared to liver tissue on the 1st postoperative day only on coronal T2 weighted (T2 W) images for time concerns and limitation of anaesthesia. Intraperitoneal Surgicel pieces were scanned with liver tissue comparison on the axial plane in the T2 W sequence easily due to their proximity. Coronal reformatted images of CT permitted comparison of the densities of Surgicel pieces with other visceral tissues. Lower, similar, and higher intensities and densities of Surgicel pieces produced by cross-sectional imaging to the viscera and tissues were recorded and tabulated. Follow-up images were compared to the first day's scan images.

3. Results

All guinea pigs completed the study without any signs of surgical site infection. The CT scans of both intraperitoneal and retroperitoneal groups revealed no remnants of Surgicel on the 4th postoperative day, and the CT scans were cancelled afterwards. The MRI scans of both intraperitoneal and retroperitoneal groups revealed no remnants of Surgicel at the 14th postoperative day and the MRI scans on the 21st and 28th days were cancelled. In order to double-check the accuracy of the MRI scan findings, all animals were reoperated on the 21st day, and none of the absorbable haemostats were found at the surgical sites.

3.1. MRI findings

All pieces of Surgicel in both groups showed internal heterogeneous and punctuate signal void dots and a hypointense peripheral zone like a capsular wall.

In the retroperitoneal group, all Surgicel pieces showed hypointense signals compared to the paravertebral muscles (PVM), fat tissue (FT), and renal cortical tissue (RCT) in T1 W images (Figure 1). All Surgicel pieces were also hyperintense compared to the PVM, 5 were hyperintense compared to the liver (L), and 5 were hypointense compared to the FT and RCT in T2 W images (Table 1).

In the intraperitoneal group, 4 Surgicel pieces were hypointense, 1 was isointense, and 1 was hyperintense when compared to the PVM in T1 W images. All Surgicel pieces showed hypointense signals compared to the L, FT, and RCT in T1 W images. All Surgicel pieces were hyperintense compared to the PVM, L, and RCT in T2 W images. All cases but 1 showed hyperintense signals compared to the FT in T2 W images (Figure 2). The remaining case, which was isointense to the FT in T2 W, presented a hyperintense appearance to the PVM in T1 W images. The case of isointense appearance in T1 W images compared to the PVM was also hyperintense compared to the FT in T2 W image (Table 1).

In the follow-up period, 2 cases of the retroperitoneal implantation disappeared in T1 but remained similar in T2 W images. One case changed its hypointense appearance compared to FT and RCT to hyperintense in T2 W images. Three other cases maintained their hyperintense signals in T2 W images until fading in the second week.

3.2. CT findings

All of the cases in either group revealed heterogeneous images with a small central punctuate area. All retroperitoneal Surgicel pieces were hyperdense when compared to FT. Four cases showed similar density when compared to L and PVM. The remaining 2 cases were hypodense when compared to L, and 1 was hypodense and the other was hyperdense compared to PVM. In terms of contrast to RCT, hypo-, iso-, and hyperdense images were obtained equally (Table 2).

All cases of intraperitoneal implantation were hypodense compared to the PVM and L. Five cases were

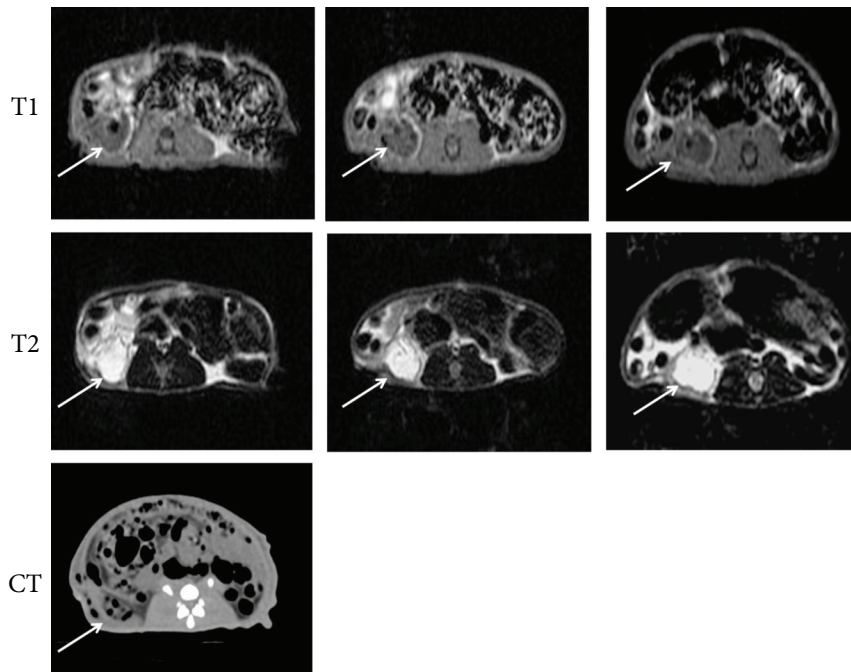


Figure 1. Three consecutive MRI images of the same animal in the retroperitoneal group on the 1st, 4th, and 7th postoperative days and the CT image on the 1st postoperative day (the white arrow indicates Surgicel).

isodense to the FT and hypodense compared to the RCT. The case that was hyperdense when compared to FT was also hyperdense compared to RCT on CT scan (Table 2).

4. Discussion

Surgicel, oxidised regenerated cellulose, is a topically applied bioabsorbable haemostatic agent. It is still a relatively well-known agent for intraoperative haemostasis, while new haemostatic materials are being discovered and their potential for bleeding cessation are being scrutinised in animal experiments (4).

Surgicel is widely used in open and laparoscopic cases of abdominal and urologic surgeries. In the early postoperative period, when these cases are complicated and require a postoperative radiological evaluation,

clinicians and the radiologists generally face a radiological dilemma as the radiological images of Surgicel generally get confused with an abscess or ongoing oozing. Furthermore, the literature is not informative about the radiological images of its postoperative course, as most of the relevant publications are case reports and limited case series. Neither the surgical area nor the time of postoperative evaluation is consistent in these publications. That is why we aimed to evaluate its presence at 2 different anatomic sites (intraperitoneal vs. retroperitoneal) on consecutive days and designed an experimental study.

There are limited data in the literature about Surgicel in terms of its typical radiological images. Despite the lack of specific diagnostic radiological signs of oxidised cellulose, some of the radiological images suggest its existence in

Table 1. MRI results of the study groups on the 1st postoperative day (PVM: paravertebral muscle, FT: peripheral fat tissue, L: liver, RCT: renal cortical tissue, X: MRI not performed).

Groups	Signal	T1 W				T2 W			
		PVM	FT	L	RCT	PVM	FT	L	RCT
Retroperitoneal	Hypointense	6	6	X	6	-	5	-	5
	Isointense	-	-	X	-	-	1	1	-
	Hyperintense	-	-	X	-	6	-	5	1
Intraperitoneal	Hypointense	4	6	6	6	-	-	-	-
	Isointense	1	-	-	-	-	1	-	-
	Hyperintense	1	-	-	-	6	5	6	6
	Total	12	12	6	12	12	12	12	12

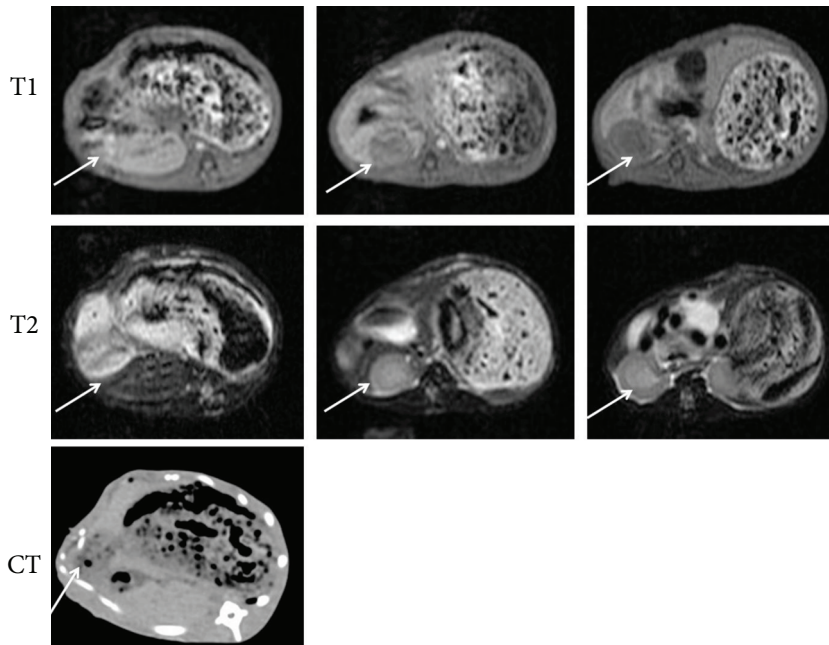


Figure 2. Three consecutive MRI images of the same animal in the intraperitoneal group on the 1st, 4th, and 7th postoperative days and the CT image on the 1st postoperative day (the white arrow indicates Surgicel).

the surgical area. When used in large amounts, it appears as a linear band of increased density on conventional X-rays (5). On ultrasound it simulates a heterogeneous hypodense echogenic appearance with a dark acoustic shadowing with or without peripheral fluid accumulation (6). Its heterogeneity is generally due to the focal linear air accumulation inside the haemostatic material. On CT, it shows up as a heterogeneous mass similar to that of an abscess or a haematoma formation (1).

The CT findings of the Surgicel in either group in our study revealed heterogeneous images with small central punctuate areas due to the gas trap within the haemostat. The density of the Surgicel shows different characteristics when compared with the surroundings in either group. The haemostat was found to be mostly hypodense when compared to surroundings in the intraperitoneal group

whereas it was found to present heterogeneous images when compared to surroundings in the retroperitoneal group. In an earlier study, Young et al. reported the postoperative CT appearances of 5 different cases and concluded that the CT findings of Surgicel are compatible with the findings of a so-called mass with mixed attenuation in or near the operative site (1). They recommended being alert in case of postoperative masses with focal and linear gas collections without fluid level in CT scans and to revise the history of the patient. In a more recent study, Sandrasegaran et al. evaluated the CT findings of gelatine bioabsorbable haemostat and suggest considering the linear arrangement of gas bubbles without fluid levels, steady-state positioning of bubbles at consecutive scans, and the absence of an enhancing wall in order to differentiate the haemostat from an abscess (3). While evaluating the CT and MRI

Table 2. CT results of the study groups at the 1st postoperative day (PVM: paravertebral muscle, FT: peripheral fat tissue, L: liver, RCT: renal cortical tissue).

Groups	Finding	PVM	FT	L	RCT
Retroperitoneal	Hypodense	1	-	2	2
	Isodense	4	-	4	2
	Hyperdense	1	6	-	2
Intraperitoneal	Hypodense	6	-	6	5
	Isodense	-	5	-	-
	Hyperdense	-	1	-	1
	TOTAL	12	12	12	12

scans, we realised that the small gas accumulation inside the haemostat was more apparent in CT images than in T1 W sections. Even though CT scans reveal more apparent views of Surgicel, this finding is limited to the very early postoperative evaluation. MRI seems to be superior in revealing the haemostat in the late term.

In this study, we found apparent hypointense signals of Surgicel in T1 W images and apparent hyperintense signals in T2 W images in the intraperitoneal group. In a study by Hoeffner et al., the MRI appearance of an intraperitoneal gelatine sponge, another haemostatic agent, was evaluated (7). Likewise, the researchers noted a hypointense image of the sponge in T1 W and a hyperintense image when compared with the liver with a persisting hypointense focus in T2 W images. In this study, we also found apparent hypointense signals of Surgicel in T1 W images and apparent hypointense signals when compared to FT and RCT, and hyperintense signals when compared to PVM and L in T2 W images in the retroperitoneal group. The similar findings for Surgicel in T1 W images but the slightly different findings in T2 W images in either group may also be due to the anatomic positioning of the haemostat (intraperitoneal vs. retroperitoneal).

In a previous study, Oto et al. presented the early and late postoperative MRI findings of Surgicel in 6 patients who underwent laparoscopic cryoablation of renal masses and laparoscopic excision of an adrenal mass [2]. They stated that oxidised cellulose applied to the surgical area appeared isointense to slightly hyperintense when compared to PVM in T1 W images and hypointense when compared to PVM, FT, and kidney in T2 W images on the 1st postoperative day. The differences between the findings of Oto et al. and those of our study could be related to the surgical procedures. It is probable that the cryoablation of

the renal masses resulted not only in bleeding but also in urinary leakage, and it is possible that the mixture of blood and urine absorbed by Surgicel presented different MRI characteristics than the simple oozing created in our study. In 1985, Brown et al. studied the MRI relaxation times of different body fluids and stated that total protein content, osmolality, and specific gravity could alter these values (8).

It is shown that Surgicel consists of uronic acid and fibrous elements. In 2 different studies, Pierce et al. demonstrated the fate of Surgicel at the implantation sites (9,10). They showed that the first 18 h after implantation are needed for degradation of the uronic acid component and the following 30 h are needed for phagocytosis of the fibrous component by macrophages without resulting in a foreign body reaction. In the follow-up period, we realised that the homogeneity of the haemostat is increased while the gradual size is decreased with stable signal intensity in most cases. This finding is also compatible with the findings of Hoeffner et al. We also realised a longer resorption period for retroperitoneally applied Surgicel. It is accepted that the resorption time is inversely proportional to the amount of the haemostat used, saturation degree with the blood, and blood flow to the tissue bed (1). As the same amount of haemostat was applied to all animals, it is possible that the blood flow to either site (intraperitoneal vs. retroperitoneal route) is the key factor of this time difference.

To conclude, we evaluated the postoperative CT and MRI appearances of Surgicel located intraperitoneally and retroperitoneally and found that they could appear radiologically distinct due to the differences in anatomical spaces. We believe that considering the surgical site and the anatomical spaces while evaluating postoperative changes with the knowledge of Surgicel could help clinicians to evaluate the situation.

References

1. Young ST, Paulson EK, McCann RL, Baker ME. Appearance of oxidized cellulose (Surgicel) on postoperative CT scans: similarity to postoperative abscess. *Am J Roentgenol* 1993; 160: 275–7.
2. Oto A, Remer EM, O'Malley CM, Tkach JA, Gill IS. MR characteristics of oxidized cellulose (Surgicel). *Am J Roentgenol* 1999; 172: 1481–4.
3. Sandrasegaran K, Lall C, Rajesh A, Maglinte DT. Distinguishing gelatin bioabsorbable sponge and postoperative abdominal abscess on CT. *Am J Roentgenol* 2005; 184: 475–80.
4. Huri E, Akgül KT, Yücel MÖ, Astarıcı HM, Üstün H, Germiyanoğlu RC. The second step in vitro trial of Ankaferd® Bloodstopper®: comparison with other hemostatic agents. *Turk J Med Sci* 2011; 41: 7–15.
5. van Gelderen F, Swinnen J. Appearance of oxidized cellulose (Surgicel) on abdominal radiographs. *Am J Roentgenol* 1996; 167: 1593.
6. Melamed JW, Paulson EK, Kliewer MA. Sonographic appearance of oxidized cellulose (Surgicel): pitfall in the diagnosis of postoperative abscess. *J Ultrasound Med* 1995; 14: 27–30.
7. Hoeffner EG, Crowley MG, Soulen RL. MR imaging appearance of intraperitoneal gelatin sponge in mice. *J Magn Reson Imaging* 1992; 2: 63–7.
8. Brown JJ, vanSonnenberg E, Gerber KH, Strich G, Wittich GR, Slutsky RA. Magnetic resonance relaxation times of percutaneously obtained normal and abnormal body fluids. *Radiology* 1985; 154: 727–31.
9. Pierce AM, Wiebkin OW, Wilson DE. Surgicel: its fate following implantation. *J Oral Pathol* 1984; 13: 661–70.
10. Pierce A, Wilson D, Wiebkin O. Surgicel: macrophage processing of the fibrous component. *Int J Oral Maxillofac Surg* 1987; 16: 338–45.