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Title:

Carbon dioxide embolism during transanal total mesorectal excision: A hint of prevention from a case report

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Running title: Prevention of CO_2 embolism during TaTME

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ABSTRACT

Transanal total mesorectal excision is a relatively new approach for treating lower rectal cancer. Carbon dioxide embolism is a critical complication of this procedure. We reported the case of a 69-year-old man with lower rectal cancer who underwent transanal total mesorectal excision followed by laparoscopic low anterior resection. He had a sudden intraoperative carbon dioxide embolism during the transanal mesorectal excision. During the ventral dissection of the rectum, end-tidal carbon dioxide and blood oxygen saturation suddenly decreased. We stopped the insufflation of carbon dioxide and suspended the procedure. There was no circulatory collapse, and the vital signs gradually recovered; therefore, we resumed the surgery approximately 30 minutes later and completed it without additional complications. Upon reviewing the video, we found a small injured vein that would aspirate carbon dioxide. These findings suggested that careful hemostasis is essential to prevent carbon dioxide embolus during transanal total mesorectal excision.

KEY WORDS: carbon dioxide embolism, prevention, transanal total mesorectal excision

INTRODUCTION

Transanal total mesorectal excision (TaTME) is becoming a widely used technique for treating lower rectal cancer. Carbon dioxide (CO_2) embolism is a rare but relatively unique complication of TaTME among other anorectal procedures[1]. Retrospective surveys have reported that the frequency of symptomatic CO_2 embolization is 0.4–3.0%[2,3]. The causes of this phenomenon are (1) a high risk of injury to the small vessels around the prostate or vagina, which directly enters the inferior vena cava, (2) low central venous pressure because of the intraoperative Trendelenburg position, and (3) the use of a continuous CO_2 insufflation system. Some cases could not avoid changing or postponing the planned procedure[2]. Therefore, CO_2 embolism should be prevented during TaTME. Herein, we reported a case of CO_2 embolism during TaTME and suggested its prevention from a surgical video review.

CASE PRESENTATION

The patient was a 69-year-old man diagnosed with a lower rectal adenocarcinoma, classified under clinical stage T3N1M0, stage IIIB according to the 8th edition of TNM classification4. Colonoscopy revealed a half circumferential type 2 tumor 5.0 cm from the anal verge (Fig. 1). The patient was scheduled to undergo TaTME followed by laparoscopic super-low anterior resection. We attached a purse-string suture to the lower rectum from the anal side, placed the GelPOINT Path, and insufflated CO_2 using the AirSeal® device. The intrapelvic pressure was set at 10 mmHg with high-flow smoke evacuation. During the ventral side of the dissection of the rectum near the prostate, we stopped the bleeding from small vessels with a monopolar electrode. End-tidal CO_2 ($EtCO_2$) suddenly dropped from 39% to 16%, and blood oxygen saturation (SpO_2) decreased from 94% to 83% (Fig. 2). The anesthesiologist increased the fraction of inspired oxygen to 100%, and the surgeons stopped CO_2 insufflation. There was no circulatory collapse. The procedure was suspended. Thirty minutes after the event, $EtCO_2$ and SpO_2 gradually recovered. Considering the short clinical course, we suspected a CO_2 embolism. We resumed the procedure and almost completed the dissection to the height of the seminal gland. We then performed a laparoscopic transabdominal approach including residual dissection of the colon and rectum, lymph node dissection, and anastomosis. The operative time was 507 min, and the blood loss was 200 ml.

Postoperatively, contrast-enhanced computed tomography (CT) was done before extubation. It showed a small amount of air in the bilateral femoral vein, but no pulmonary artery emboli or deep venous thrombosis (Fig. 3). The patient was extubated the day after surgery and discharged on postoperative day 18 without any complications. The pathological stage was T3N0M0 stage IIA with a negative circumferential rectal margin. Upon reviewing the surgical videos just before the CO_2 embolism, an injured small vein with up-and-down blood surface movement, but blood was not leaked from the injured surface of the vein. We suspected the vein to be responsible for CO_2 gas aspiration (Fig. 4, Supporting Video. 1).

DISCUSSION

Controlling bleeding is essential for the prevention of CO_2 embolism. One article published a video showing CO_2 spouting out from the injured vein with suction[3]. In our case, a small vein was injured, but there was no blood leakage. The blood surface moved up-and-down in the rhythm to the central venous pressure. The phenomenon could be seen because the intracorporeal pressure of the operative field was a little bit higher than that of the vein. This could be the entry of CO_2 gas. Intraoperatively, we overlooked the injured venous because there was no blood coming out of the vessel. Thus, we recommend the surgical team to pay attention to the slight findings of damaged vessels; the small hole that allows CO2 entry should be closed.

In contrast, laparoscopic hepatectomy utilized a high pneumoperitoneum pressure which reduces blood loss, especially from the hepatic vein. The surgeons believed that the high absorbability of CO_2 gas has an advantageous effect on this technique. CO_2 gas can be quickly absorbed; therefore, it does not cause embolization. The reported frequency of CO_2 embolism during laparoscopic hepatectomy was 0.2%[5]. However, hemostasis with a high gas pressure is not recommended for TaTME. Patients undergoing TaTME could be more vulnerable to CO_2 embolus than laparoscopic hepatectomy because of the patient's position and narrow surgical field.

The patient's postoperative CT scan showed a small amount of intravenous gas

in the bilateral femoral vein. Previous reports have mentioned the high frequency of subclinical CO_2 aspiration detected by transesophageal echocardiography (69% in laparoscopic cholecystectomy[6] and 100 % in laparoscopic hysterectomy[7]). In this case, postoperative CT revealed that the gas still stayed in the veins and was asymptomatic. The phenomenon could suggest that subclinical CO2 gas entry also occurs during TaTME as in other laparoscopic surgeries.

An abrupt decrease in $EtCO_2$ is the first sign of CO_2 embolism in an intubated patient[8]. During TaTME, 88% of CO_2 embolism cases showed this clinical sign, followed by hypotension and reduced SpO_2[2]. The differential diagnosis is pulmonary embolism; however, the typical presentation of pulmonary embolism is postoperative. The frequency of postoperative pulmonary embolism was 0.2%, according to the big data of laparoscopic cholecystectomy[9]. The frequency of intraoperative pulmonary embolism is unknown; however, it is possibly lower than that of postoperative pulmonary embolism. Echocardiography is essential for diagnosing CO2 embolism. Transesophageal echocardiography is especially useful for finding air bubbles in the right atrium and ventricle[10]. If CO_2 embolism occurs and cardiopulmonary collapse is not severe, we can wait until the vital signs are stabilized with CO_2 absorption. Approximately 85% of the cases could resume the procedure with or without delay[2]. In our case, we continued the

TaTME and almost completed the planned dissection after the vital signs were stabilized. We performed a transabdominal approach with laparoscopy because CO_2 aspiration to the systemic venous circulation would not occur during this approach. However, if stabilizing the vital signs is difficult, we should postpone the remaining parts of surgical procedure or convert to open surgery.

In conclusion, attention should be paid to even slight bleeding for the prevention of CO_2 embolism during TaTME.

ACKNOWLEDGMENT

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CONFLICT OF INTEREST

All authors have no conflict of interest about this study.

AUTHOR CONTRIBUTION

Case report concept; MF, KK, drafting of the manuscript; MF, KK, critical revision of the manuscript; SH, administrative, technical, or material support; CI, HK, KU, SF, NO, KI, TY, YK, MT, YA, FN.

ETHICS STATEMENT

This study was approved by the ethics committee of the Teine Keijinkai Hospital. Written

informed consent was obtained from the patient for the publication of this case report and accompanying images.

DATA AVAILABILITY STATEMENT

The data that support the findings of this report are available from the corresponding author upon reasonable request.

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SUPPORTING INFORMATION

Additional supporting information is in the online version of the article at the publisher's website

FIGURE LEGENDS

Fig. 1 Colonoscopy showed a half circumferential type 2 tumor at 5.0 cm from the anal verge.

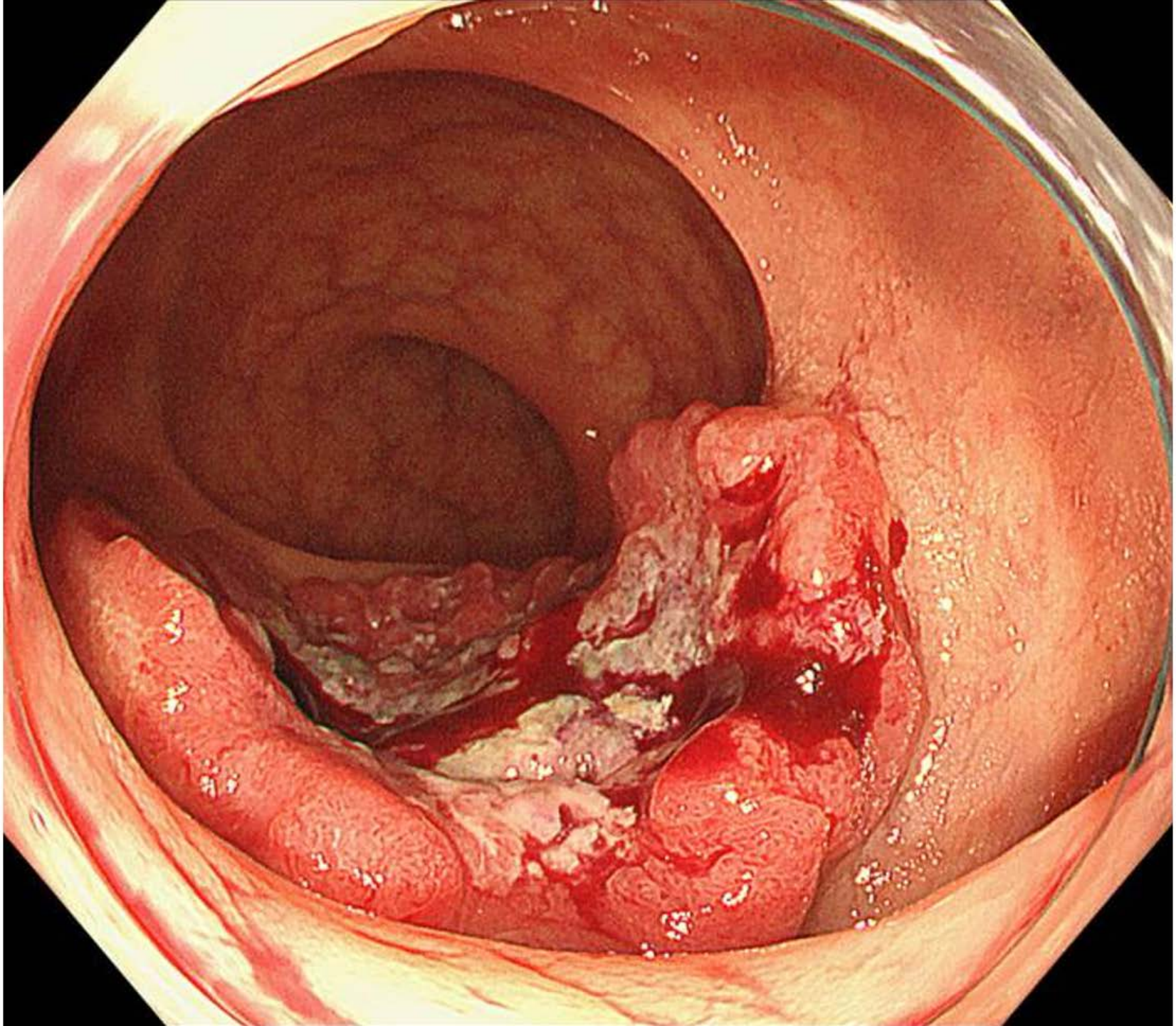
Fig. 2 Arranged relevant portion of anesthesia monitor record. The red arrowhead shows the timing of the event with abrupt drop of end tidal carbon dioxide and blood oxygen saturation (SpO_2). Blood SpO2 (%), end-tidal CO_2 ($EtCO_2$, %), systemic blood pressure (sBP, mmHg), diastolic blood pressure (dBP, mmHg), and heart rate (HR, beats per minute).

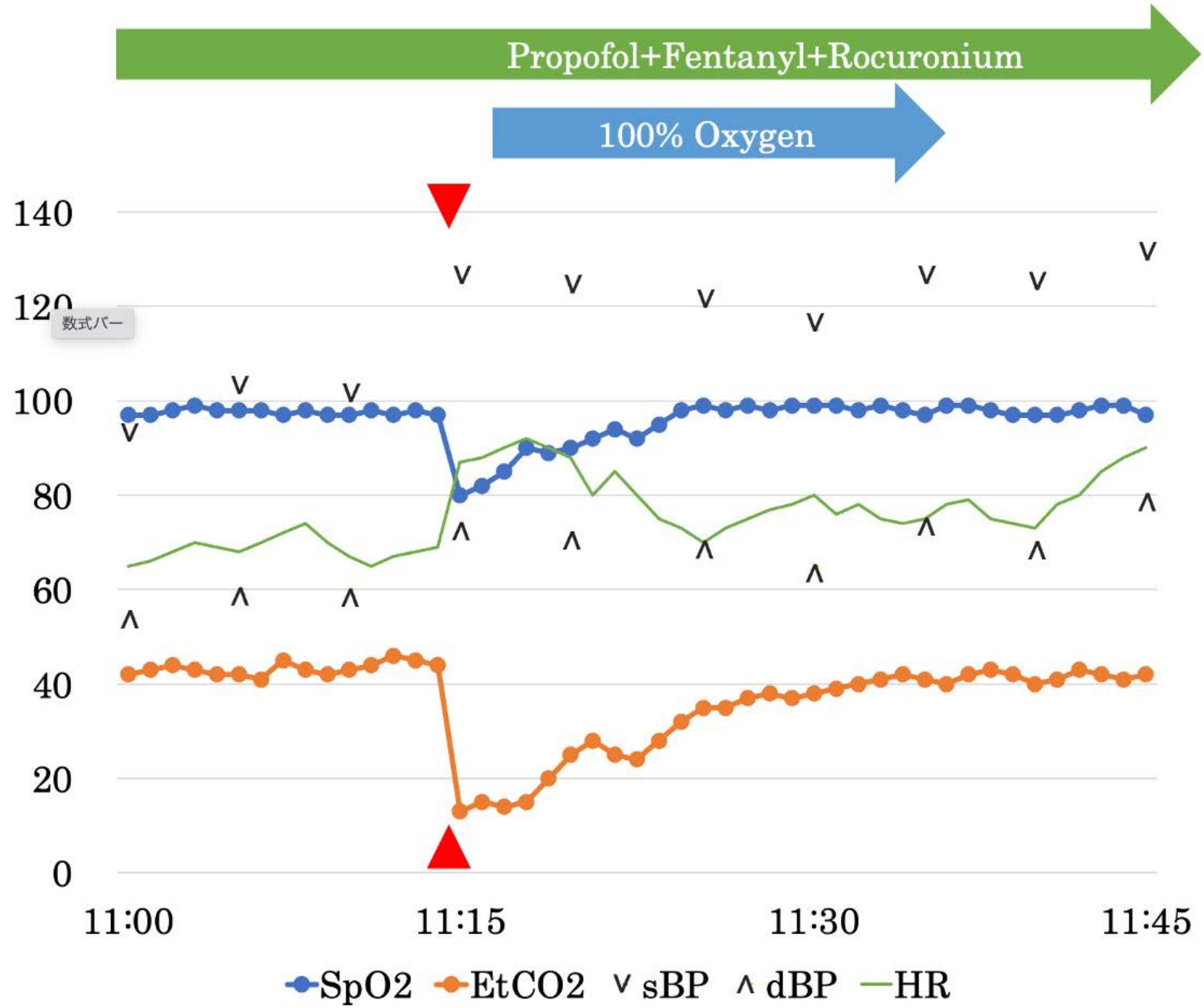
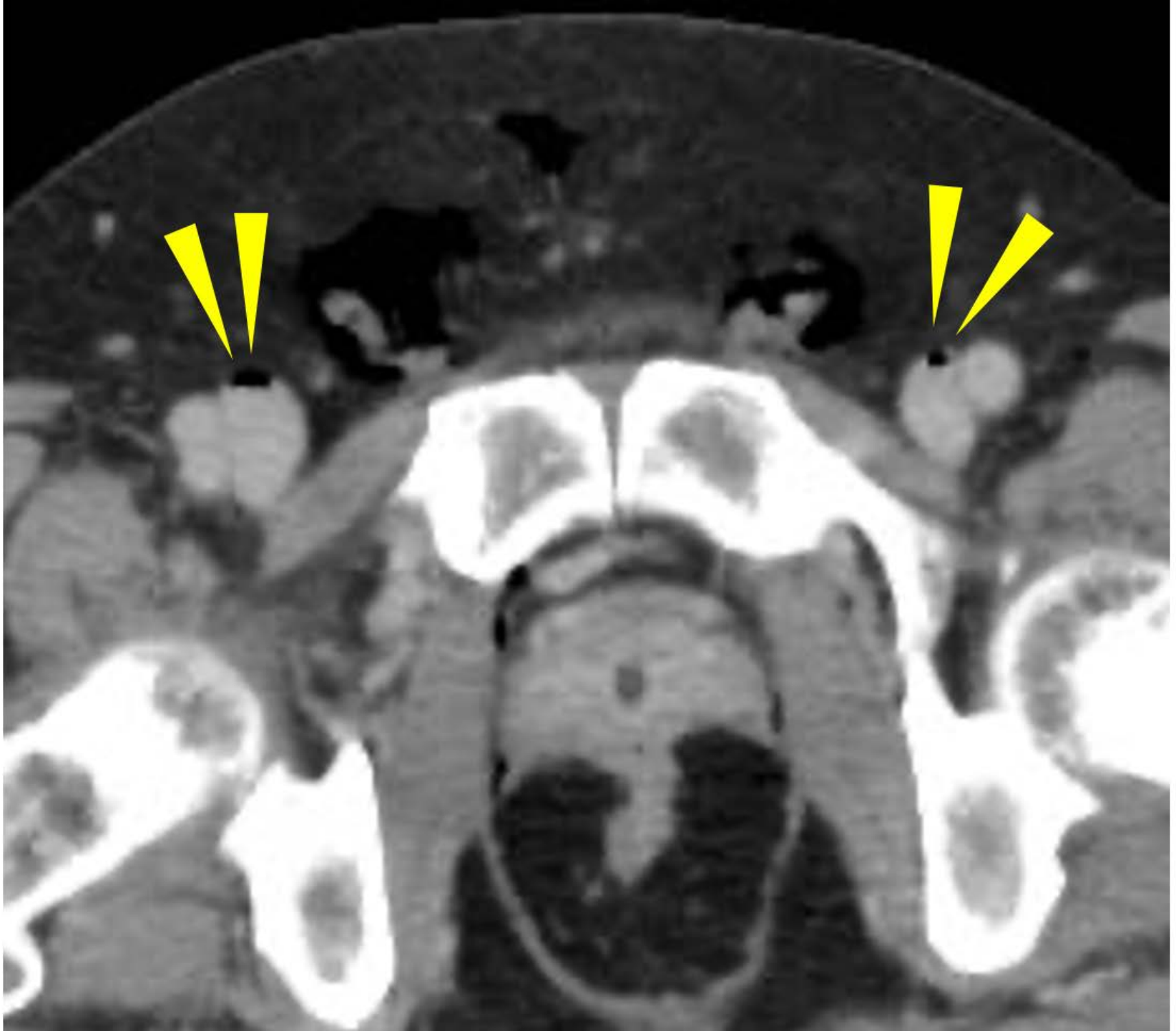
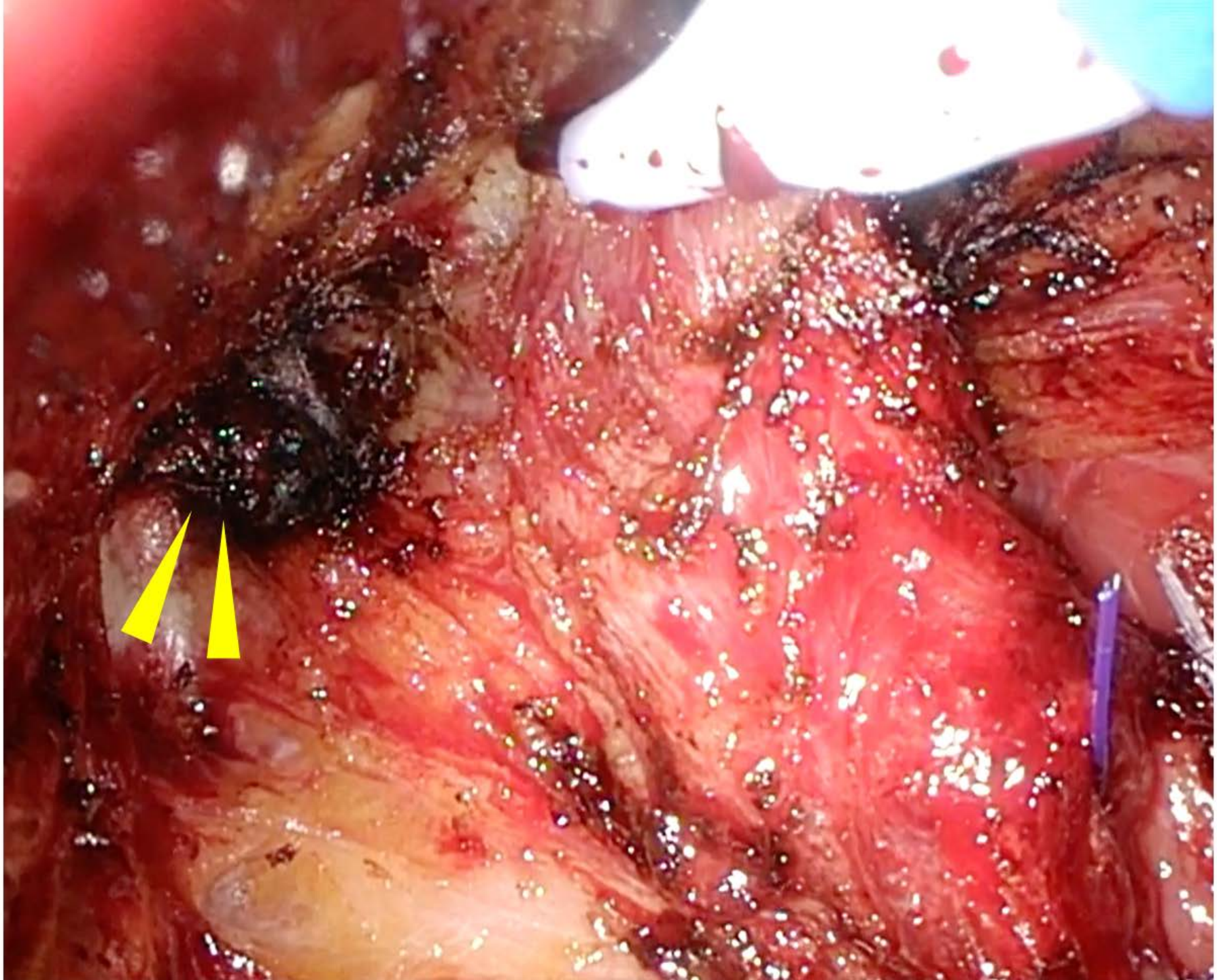
Fig. 3 Postoperative contrast-enhanced computed tomography showed a small amount of air in the bilateral femoral vein (arrowheads).

Fig. 4 During a ventral side dissection of the rectum near the prostate, there was an injured small vein, but there was no blood leakage. The surface of the blood had an up-and-down movement. Just after this, the CO_2 embolism occurred. CO_2 gas was aspirated there (arrowheads).

SUPPORTING VIDEO LEGEND

Supporting Video. 1 The video shows the scene when CO_2 embolism occurred. We found an injured small vein probably responsible for CO_2 aspiration.




Propofol+Fentanyl+Rocuronium
100% Oxygen
140
120
100
80
60
40
20
0
11:00
11:15
11:30
11:45
SpO2
EtCO2
sBP
dBP
HR