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CLINICAL REPORT

Two cases of compartment syndrome of the lower extremities during surgery for gynecological malignancies

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Abstract Two cases of compartment syndrome of the lower extremities occurring during surgery for gynecological malignancies are reported. In addition to the risk from being in the lithotomy position for over 4 h, these two cases were believed to have been caused by the combined use of a disposable wound retractor and abdominal retractors to secure the operative field. This conclusion is based on the fact that an abrupt increase in partial pressure of end-tidal CO_2 ($ETCO_2$) was observed when wound drapes and abdominal retractors were removed approximately 4 h after the start of surgery. Prolonged compression of the external iliac vein by a disposable wound retractor and abdominal retractors is believed to have induced congestion of the lower extremities, eventually resulting in compartment syndrome. To verify this, during subsequent surgeries of the same type, changes in the diameters of femoral arteries and veins when a disposable wound retractor and abdominal retractors were used were monitored using an ultrasound device, and the findings confirmed that changes in vascular diameter do occur.

Keywords Compartment syndrome · Gynecological malignancies · Abdominal retractors · Disposable wound retractor

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Introduction

Compartment syndrome of the lower extremities is a serious condition in which the pressure inside the compartments increases as a result of swelling or bleeding in tissues due to a fracture or a muscle or vascular injury, leading to the compression of blood vessels and nerves and causing nerve damage and tissue necrosis which, if conditions persist, can lead to renal failure. Most reports of surgically related compartment syndrome involve gynecological surgical cases [1–5], in which it is believed that the condition results from the patient spending a prolonged period in the lithotomy position. However, at our facility, we have had no cases of compartment syndrome during similar types of lower abdominal surgery with lithotomy, and a search of the literature revealed only a few reports of such cases in this field of surgery in the last 10 years [6, 7]. The main reason why so many cases occur in the field of gynecology and obstetrics—in addition to period of time spent in the lithotomy position—is the characteristics of the procedures used in gynecological surgery. In this paper, the proven causes of two cases of compartment syndrome that occurred during surgeries for gynecological malignancies are reported.

Case report

The backgrounds of the patients discussed in the present case report and details of the surgeries performed on them are shown in Table 1. In these two cases, after surgery was initiated, a combination of a disposable wound retractor and abdominal retractors was installed (Fig. 1) to secure the operative field. When these devices were removed about 4 h after the start of surgery, an abrupt increase in the

partial pressure of $ETCO_2$ (+10–15 mmHg) was observed (Fig. 2). There was no color change in the intestinal tract, etc., suggestive of ischemia. Postoperatively, the patients began to complain of pain in the lower legs; swelling at the same site and tenderness in the swollen area were observed. In case 1, contrast-enhanced CT of the lower extremities revealed swelling, and marked inflammatory changes in the soleus muscle and gastrocnemius muscle were observed (Fig. 3). Compartment syndrome was suspected, and when the pressure inside the compartments of the lower legs was measured, marked pressure elevations of the anterior compartment (60 mmHg) and posterior compartment (80 mmHg) were found. Blood tests showed that GOT was 102 IU/L, CK was 15,307 IU/L (Table 2), and urinalysis showed occult blood of 4+ and myoglobin 210,000 ng/mL. Fasciotomy of the lower left leg was conducted immediately. In case 2, MRI revealed contusions of the gastrocnemius muscles of both legs (Fig. 4) (no abnormalities in CT). Blood tests showed that CK was 11,703 IU/L, GOT was 253 IU/L, and GPT was 67 IU/L (Table 2). Because these symptoms and findings were mild, no special procedures were implemented according to the judgement of the orthopedic surgeon. Fortunately, these patients recovered with no residual renal or nerve damage.

Table 1 Backgrounds of the two cases reported in this work and details of the surgeries performed on them

	Case 1	Case 2
Age (years)	40	29
Body height × body weight	164 cm × 51 kg	159 cm × 56 kg
Diagnosis	Uterus cancer	Ovarian cancer
Surgery	Radical hysterectomy	Oophorectomy
Operation time (min)	424	292
Blood loss (g)	698	451

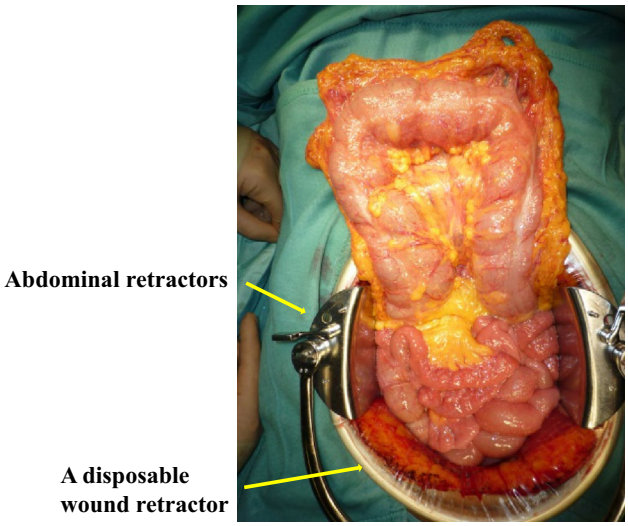

Fig. 1 Operative field with the combined use of a disposable wound retractor and abdominal retractors

Discussion

Compartment syndrome is characterized by the sudden onset of the following clinical symptoms (the five "P"s): pain, pallor, puffiness, paralysis, and pulselessness. Definitive diagnosis is obtained by confirming that the clinical symptoms mentioned above are present and measuring the compartment pressure. Fasciotomy is indicated at ≥30 mmHg (normal pressure ≤8 mmHg) [8]. Factors involved in the perioperative occurrence of compartment

Fig. 2 Changes in the partial pressure of end-tidal CO_2 in the anesthesia records of cases 1 and 2

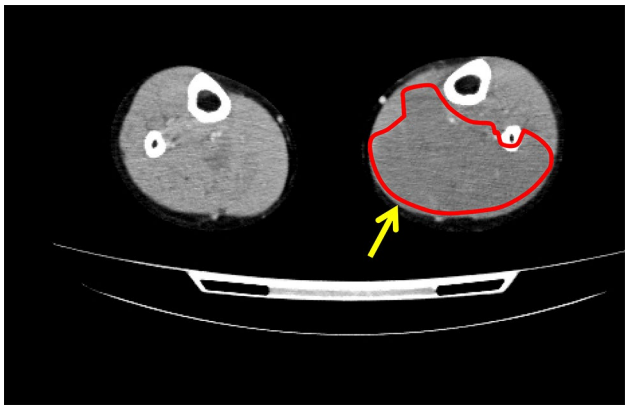

Fig. 3 Contrast-enhanced CT image of the lower extremities after surgery in case 1. Inflammatory changes in the soleus muscle and gastrocnemius muscle

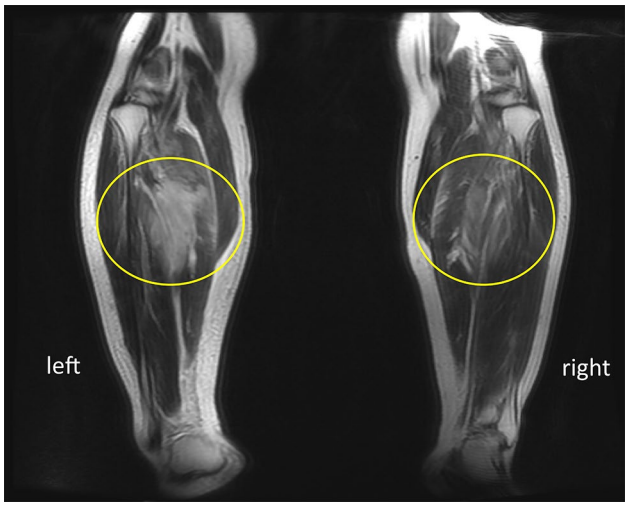

Fig. 4 MRI image of the lower extremities after surgery in case 2. Contusions of the gastrocnemius muscles of both legs (*left* > *right*)

Table 2 Changes in blood test parameters

	Case 1		Case 2	
	Pre-operation	Post-operation	Pre-operation	Post-operation
WBC ($\times 10^9$/L)	2.8	3.5	4.8	8.3
RBC ($\times 10^{12}$/L)	2.66	2.53	4.32	3.70
Hb (g/dL)	9.2	9.0	12.3	10.5
Ht (%)	28.4	27.8	37.7	32.6
Plt ($\times 10^9$/L)	101	57	195	150
GOT (U/L)	26	159	16	253
GPT (U/L)	27	45	14	67
Na (mmol/L)	141	142	140	137
K (mmol/L)	4.0	4.1	3.8	4.0
Cl (mmol/L)	104	108	105	106
D-dimer (μg/mL)	0.8	1.8	0.9	2.0
CK (U/L)	48	15,307	54	11,703

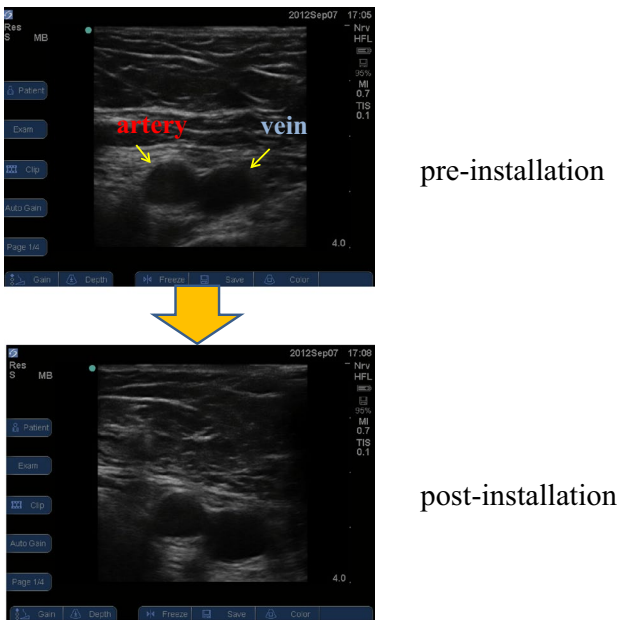

Fig. 5 Ultrasound images of the femoral vein and artery; changes in the vascular diameter of the femoral vein when a disposable wound retractor and abdominal retractors are installed in the surgical field are shown. In this case, the diameter expanded from 10 mm pre-installation to 13 mm post-installation.

syndrome include (1) prolonged surgery of 5 h or more, (2) lithotomy position, (3) peripheral vascular disorder, (4) elastic stockings, (5) intermittent placement of a pneumatic compression device on the lower extremities, (6) low blood pressure, (7) low body temperature, (8) dehydration, (9) obesity, (10) compression of the lower extremities by the surgeon, and (11) traction and compression of blood vessels from manipulation inside the pelvis [1]. The factors involved with these patients were (1), (2), (5), and (11) in case 1, and (2), (5), and (11) in case 2. In addition to these factors, these patients shared another factor. This was the combined use of a disposable wound retractor and abdominal retractors. A disposable wound retractor is a vinyl sheet suspended between two flexible plastic circular frames. By placing this, the wound is opened in a circular shape and the operative field is secured. In addition, the risk of wound infection is reduced [9–13]. In our hospital, in gynecological surgeries, our procedure is to install an abdominal retractor in addition to a wound protector in order to secure a wider operative field. An abdominal retractor is placed in the groin to secure a wider field of vision inside the pelvis. However, this applies considerable force to the groin, and

it is believed to compress blood vessels in the vicinity. A phenomenon that corroborates that this was the cause of these occurrences in these cases was the occurrence of an abrupt increase in the partial pressure of $ETCO_2$ when the disposable wound retractor and abdominal retractors were removed. CO_2 produced by the metabolism of tissue at the sites where blood flow had been obstructed flows out to the systemic circulation due to the resumption of blood flow, resulting in a rise in the partial pressure of $ETCO_2$. Based on the postoperative clinical symptoms and imaging findings, we believed that congestion had occurred in the lower extremities as a result of prolonged compression of the external iliac vein, and that internal bleeding associated with the congestion in the muscular coat had also occurred. During these surgeries, we checked the positions of the lower extremities every hour. We can therefore exclude the influence of the direct compression associated with the lithotomy positioning devices. In fact, the considerable change in the partial pressure of $ETCO_2$ after the change of position (from lithotomy to supine) at the end of surgery was not recognized. In order to verify this, these assumptions were tested in 5 patients who underwent surgery for gynecological malignancies. An ultrasound device was used to measure changes in the vascular diameter of the femoral vein when a disposable wound retractor and abdominal retractors had been installed. There were no changes in 4 of the 5 patients. However, in one patient, the diameter expanded from 10 to 13 mm (Fig. 5), and the diameter decreased after the removal of abdominal retractors. This phenomenon suggests that these attachments may extend the tissues around the external iliac artery and vein, and the vein could be lifted and compressed. As a result of this, congestion could occur due to the long hour compression of the external iliac vein in the lower extremities. Based on the above, it was concluded that the combined use of a disposable wound retractor and abdominal retractors could influence the blood flow to the lower extremities.

The actual procedures used in surgery for gynecological malignancies often involve a significant period of time spent operating in the area around the external iliac arteries and veins, such as direct vascular compression by the surgeon's hands, and vascular compression from a gauze placed for hemostatic purposes. It is also known that, in general, the risk of compartment syndrome increases with the addition of factors such obesity when the patients spends a prolonged period in the lithotomy/Trendelenburg position [2]. Another factor that should be considered is the potential development of a congestive state as a result of impaired venous return due to deep vein thrombosis [3]. It was also reported that inappropriate placement of intermittent pneumatic compression devices or elastic stockings on the lower leg to prevent deep vein thrombosis would lead to the possibility of blood flow impairment [4]. It has also been suggested that congestion can develop due to impaired venous blood flow following repair at the site of a vascular injury [5].

In the cases reported in the present paper, it was possible to identify the cause based on changes in the partial pressure of $ETCO_2$, which is something that has not been previously described. If blood flow has been temporarily impaired with the application of some type of intraoperative procedure while the patient is in the lithotomy position for an extended period of time, changes in the partial pressure of $ETCO_2$, similar to those that occurred in these cases, can be expected to occur when the blood flow that was impaired is released. An important role of anesthesiologists is to stay alert to these changes so that a diagnosis can be made and treatment can be promptly administered to avoid lasting serious damage. Recently, a device (INVOS™) has been developed for measuring changes in the blood flow and oxygen saturation of tissues using near-infrared light at two different wavelengths, and it has been reported that changes in these values [regional saturation of oxygen (rSO_2) and blood volume index (BVI)] can be used to predict tissue ischemia and congestion, which is useful in the diagnosis of compartment syndrome [14]. In the future, the proactive introduction of such devices should lead to better control of these problems.

Conclusion

Two cases were reported in which, during surgery for gynecological malignancies, lower leg compartment syndrome occurred as a result of lower leg congestion due to stretching or compression of the external iliac vein upon the installation of a disposable wound retractor and abdominal retractors, and due to the patient being in the lithotomy position. We conclude that the combination of these devices could be a risk for lower leg compartment syndrome during lower abdominal surgery. Considering the risk of changes in blood flow in the lower legs, it is important to be alert for changes in the partial pressure of $ETCO_2$ and to monitor changes in the blood flow of peripheral tissues.

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