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Case Report

Severe liver injury successfully treated with transarterial embolization using carbon dioxide angiography: A case report

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ABSTRACT

Angiography using carbon dioxide (CO_2) has gained attention as a method of inducing active bleeding in patients for whom bleeding cannot be detected with iodine contrast medium (ICM). We experienced a case in which CO_2 angiography was performed during transarterial embolization (TAE) for severe liver injury with active bleeding. A woman in her 40s was struck by a minitruck while crossing the road and rushed to our hospital. Upon admission, she was in shock vital with blood pressure of 75/38 mmHg and pulse rate of 130 bpm. Blood transfusion was promptly started after arrival and her blood pressure increased. Abdominal ultrasonography showed echo free space in Morrison's pouch. Contrast-enhanced CT showed deep liver laceration in the right lobe and intra-abdominal hemorrhage with active bleeding. We selected TAE for hemostasis. ICM angiography showed extravasation of contrast medium from the anterior and posterior segmental branches, which was embolized with a gelatin sponge. After embolization, CO_2 angiography revealed new extravasation that could not be detected by ICM, which was additionally embolized. There was no rebleeding or pseudoaneurysm after embolization. In TAE for deep liver injury, ICM alone may underestimate active bleeding. CO_2 angiography may lead to better outcomes when injured vessels are reliably identified and TAE is performed.

Introduction

Since it was first reported by Hawkins in 1982 [1], carbon dioxide (CO_2) angiography has been used as an alternative to iodine contrast medium (ICM) in patients undergoing endovascular treatment, particularly those with renal dysfunction or allergy to iodine [2]. In recent years, CO_2 angiography has gained attention as a method of inducing active bleeding for digestive bleeding cases [3–5]. However, there are few reports on the use of CO_2 angiography in traumatic hemorrhage cases. We report the case of a patient with severe liver injury for whom CO_2 angiography was performed to induce active bleeding after a failure to detect bleeding by ICM, and who was successfully treated by transarterial embolization (TAE).

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Case presentation

A woman in her 40s with no specific medical history was hit by a minitruck while crossing the road and sent flying about 8 m. She was immediately rushed to our hospital. Her vital signs on admission included a respiratory rate of 39/min, SpO_2 of 100 % (10 L/min oxygenation), blood pressure of 75/38 mmHg, heart rate of 130 bpm, and Glasgow Coma Scale of 15 points. Abdominal sonography showed echo free space at Morrison's fossa. Fluid resuscitation and tranexamic acid (loading dose 1 g over 10 min followed by infusion of 1 g over 8 h) administration was started. Panscan CT showed right 4th–11th rib fracture, right hemothorax, pulmonary contusion, deep liver laceration of approximately 8 cm (Classification of the American Association for the Surgery of Trauma: grade IV) in the right lobe with active bleeding (Fig. 1a/b), right scapula fracture, and open fracture of the middle phalanx of the left middle finger. Her injury severity score was 36, her Revised Trauma Score was 7.55, and her estimated probability of survival was 93.4 %. We first inserted a chest drain for the pneumothorax, and intubated for flail chest. Then, TAE was performed to control the hemorrhage associated with the severe liver injury and achieve hemostasis. Angiography from the celiac artery with ICM showed extravasation of contrast medium from the anterior and posterior segmental branches of the hepatic artery, respectively, which were embolized with a gelatin sponge (GS) (Fig. 2a/b). When angiography with ICM was performed after embolization to confirm hemostasis, the active bleeding appeared to have stopped, but CO_2 angiography revealed new extravasation into the abdominal cavity (Fig. 2c). Thus, additional embolization was performed with GS, and ICM angiography indicated that the extravasation had disappeared (Fig. 2d). However, CO_2 angiography repeatedly performed from the celiac artery showed multiple extravasations, and each was additionally embolized with GS (Fig. 2e). The final confirmatory ICM and CO_2 angiography showed no obvious active bleeding (Fig. 2f). It took total 100 min to complete TAE. After TAE, her hemodynamically status stabilized with a blood pressure of 140/90 mmHg, pulse rate of 100 bpm, and she was admitted to the ICU. She was extubated on the 3rd day, and the chest drain was removed on the 4th day. During follow-up, there was a complication of hepatorrhea, which required endoscopic stenting of the right bile duct on the 24th day (Fig. 3b). The hepatorrhea gradually shrank after the stenting (Fig. 3c), and the bile duct stent was removed on the 32nd day. Thereafter, her general condition remained stable, and she was discharged on the 56th day.

Discussion

In this case, the patient was able to complete treatment for a blunt liver injury with Abbreviated Injury Scale (AIS) $\geq$4 by non-operative management (NOM). It has been reported that NOM for blunt liver injury in patients with AIS $\geq$ 4 is successful in 70 % of cases [6]. On the other hand, it has also been reported that extravasation is not detected by angiography in about 36 % of cases with extravasation of contrast medium on CT, which is the cause of NOM failure. In addition, it is estimated that fatal complications due to delayed bleeding occur in about 3 % of cases with NOM for liver injury. Thus, appropriate hemostasis in the initial TAE is important [7].

In this case, it appeared that angiography using CO_2 was able to visualize bleeding that could not be detected by ICM during TAE. As a result, the injured site could be reliably treated and postoperative rebleeding and formation of a pseudoaneurysm were prevented. There are five possible mechanisms by which CO_2 induces active bleeding: (1) a low viscosity effect, since viscosity of CO_2 is 400 times lower than that of ICM; (2) a high dissolution effect, since CO_2 is about 20 times more easily dissolved in blood than oxygen; (3) a compression effect, since volume expansion can occur after injection; (4) a vasodilation effect, since blood flow increases due to the vasodilating effect of CO_2; and (5) a thrombectomy effect, since temporary thrombi may be removed by CO_2 [5,8].There are two methods of inducing active bleeding other than CO_2, vasodilators [9] and thrombolytics [10]. However, in multiple trauma cases with hemodynamic instability, as in the present case, vasodilators have proven difficult to use because of the risk of decreasing blood pressure. Thrombolytics also may promote bleeding in multiple sites. In this regard, CO_2 has been shown to be safe, with complications generally limited to mild gastrointestinal symptoms. Although very rare, a complication of CO_2 contrast is temporary CO_2 trapping, which can cause air embolization, and intestinal necrosis should be noted, especially when used for intestinal blood flow such as the

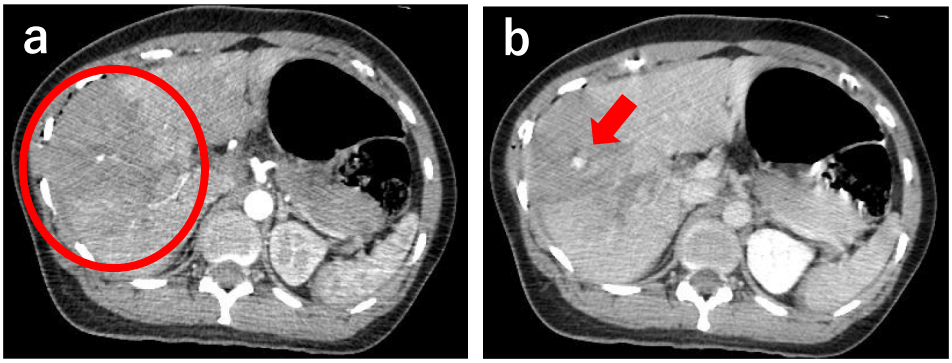

Fig. 1. Abdominal contrast enhanced CT on arrival at our hospital.
(a) Artery phase; (b) Portal phase.
An approximately 8 cm hepatic laceration of the right lobe (circle) with extravasation of contrast medium (arrow) was observed.

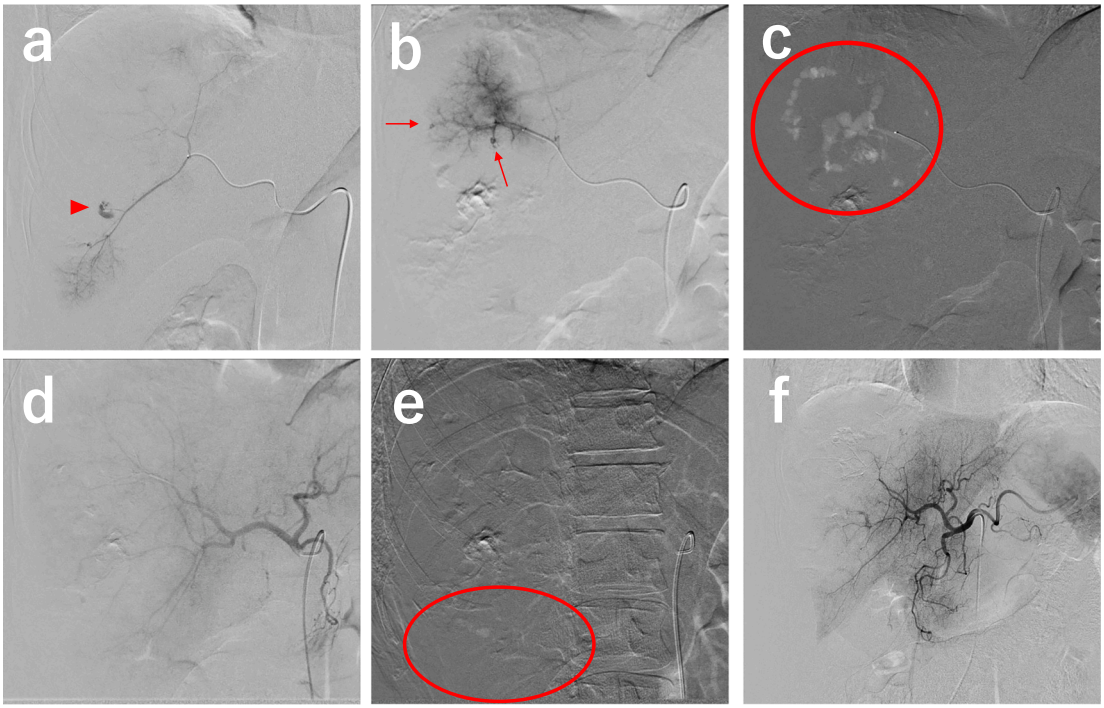

Fig. 2. Transarterial embolization findings
(a) ICM angiography of the anterior segment of the right hepatic artery revealed an extravascular leak of contrast medium (arrowhead), which was embolized with GS.
(b) Similarly, an extravascular leak of contrast material (arrow) was observed in the posterior segment of the right hepatic artery, which was embolized with GS.
(c) After embolization of the posterior segment branch, CO_2 angiography revealed a new extravascular leak (circle) into the abdominal cavity, which was additionally embolized with GS.
(d) Abdominal arteriography with ICM showed no obvious extravascular leakage. (e) Celiac arteriography with CO_2 as a contrast agent gave multiple images of extravascular leakage (circles) into the abdominal cavity, and these leakages were additionally embolized with GS.
(f) Final confirmatory contrast showed no obvious extravascular leakage image on either iodine or CO_2 contrast.

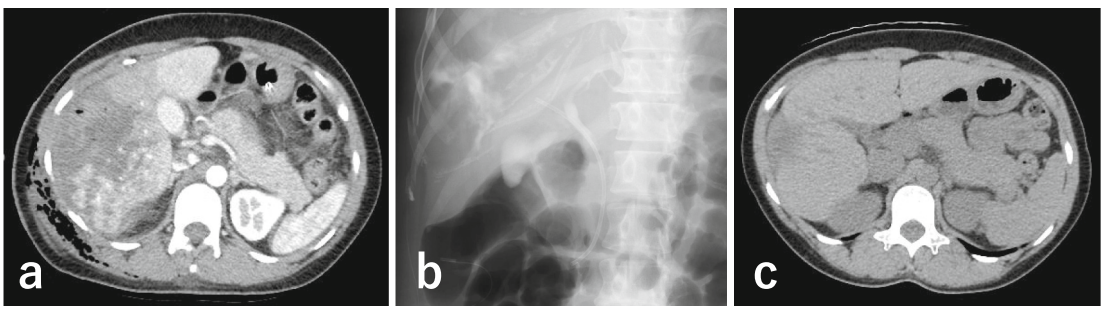

Fig. 3. Complications of hepatorrhea after transarterial embolization and bile duct drainage
(a) Contrast-enhanced CT follow-up performed on the fourth day showed no evidence of rebleeding, but the liver injury area showed mottled contrast accumulation with internal air.
(b) Endoscopic retrograde cholangiography revealed a leak of contrast medium from the right bile duct (circle), suggesting the complication of a biliary fistula, and a bile duct stent was placed in the injured area.
(c) Follow-up CT on the 52nd day after right bile duct stent placement showed resolution of ascites and reduction of biloma.

superior and inferior mesenteric arteries. Therefore, it is necessary to keep in mind that CO_2 angiography should be performed in small amounts, and if used continuously, it should be conducted at intervals of time [11].

Reports on the effectiveness of CO_2 angiography as an induction method to increase the detection rate of active bleeding are still limited, and further studies with more cases are needed.

Conclusion

When TAE is performed and NOM is selected for patients with severe liver injury, ICM alone may underestimate active bleeding. In such cases there is a risk of delayed rebleeding or pseudoaneurysm formation due to incomplete TAE. Therefore, it may be useful and important to use CO_2 to reliably identify active bleeding and perform TAE for the affected artery.

CRediT authorship contribution statement

Ryota Sasaki: Writing – original draft. **Takaaki Maruhashi:** Writing – review & editing, Conceptualization. **Muneyoshi Kim:** Data curation. **Yutaro Kurihara:** Writing – original draft, Conceptualization. **Hideo Maruki:** Data curation. **Koyo Suzuki:** Data curation. **Marina Oi:** Writing – review & editing. **Yasushi Asari:** Supervision.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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