Letter to the Editor

Real-time evaluation of active bleeding severity in soft-tissue hematomas via contrast-enhanced ultrasound: a case series

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Introduction

Soft-tissue hematomas usually occur secondary to trauma, but spontaneous hemorrhage has become increasingly common with the rise in the number of patients receiving anticoagulants (1). If a hematoma progresses rapidly, the patient will not only have clinical symptoms, such as pain and swelling, but when combined with a progressive drop in hemoglobin and blood pressure, may also experience active bleeding. Contrast-enhanced computed tomography (CECT) is a reliable imaging method for the diagnosis of active bleeding, as it can show active contrast extravasation (2). However, disadvantages, such as its unsuitability for patient movement and its results were affected by breathing in critically ill patients limit its clinical application to a certain extent. Contrast-enhanced ultrasound (CEUS) has demonstrated advantages in blood flow and perfusion evaluation (3-5). Studies have confirmed the high sensitivity and specificity of CEUS in detecting active bleeding in patients with soft-tissue hematomas (6-8), but there are few reports in the literature suggesting that CEUS can be used to assess the severity of active bleeding in soft-tissue hematomas. Therefore, in this study, we retrospectively analyzed the CEUS images of 11 patients with soft-tissue hematomas, aiming to investigate the diagnostic value and characteristic manifestations of CEUS in active soft-tissue hemorrhage.

Material and methods

Patient selection

We reviewed the medical records of patients with documented clinically suspected active bleeding in soft-tissue hematomas who were treated at Zhejiang Hospital between October 2021 and June 2023. All patients underwent conventional ultrasound and CEUS within 24 h of the discovery of subcutaneous soft tissue masses.

Methods

An ultrasound examination was performed using a color Doppler ultrasound diagnostic instrument (M9 Ultrasound System, Mindray, Shenzhen, China) equipped with both curved and linear array probes. A second-generation blood pool contrast agent (Sonovue, Bracco, Milan, Italy) composed of sulfur hexafluoride microbubbles was used as the ultrasound contrast agent. The CEUS mode began in the low mechanical index state, which was followed by the dual-amplitude mode. Next, 5 mL of physiological saline was withdrawn and injected into the contrast bottle; 1.8–2.4 mL of ultrasound contrast agent microbubble suspension was withdrawn after being shaken well and injected via the antecubital vein in a projectile fashion, which was followed by a 5-mL injection of physiological saline. A built-in counter was activated and recorded continuously

Table 1 Patient characteristics

Patient	Age (years)/sex	Cause of hematoma formation	Anatomical area	Hematoma size (cm)	Hemoglobin level (g/L)
1	46/F	Warfarin	Rectus sheath	10.5×6.6×8.4	66
2	68/M	Warfarin	Right posterior chest wall	21.0×5.0×8.4	85
3	82/F	Surgery	Left rectus sheath	20.1×2.8×6.0	97
4	58/F	Surgery	Left psoas major muscle	8.0×4.5×5.2	101
5	60/M	Aspirin and clopidogrel	Right psoas major muscle	8.6×3.5×4.3	79
6	54/M	Heparin	Right rectus sheath	7.0×4.0×5.5	108
7	81/F	Rivaroxaban	Left popliteal fossa	5.2×1.9×4.1	112
8	77/F	Surgery	Left thigh	6.1×2.2×4.8	125
9	90/M	Heparin	Right anterior chest wall	7.5×3.5×4.1	82
10	55/M	Warfarin	Left rectus sheath	6.3×3.5×4.2	92
11	75/F	Surgery	Right anterior chest wall	16.1×4.8×6.4	64

Normal range of hemoglobin level: 115–150 g/L. F, female; M, male.

while the contrast agent was injected. The suspicious area of the conventional ultrasound examination was observed first; then, the spillage and aggregation of the ultrasound contrast agent around and inside the hematoma were continuously scanned. Blood perfusion of the subcutaneous soft-tissue mass was recorded to determine the presence of active bleeding. CEUS images were analyzed by two doctors, and a final diagnosis of active bleeding was made. Computed tomography (CT) examinations were performed with a 512-slice panoramic multimodal CT (Neuviz Epoch, Neusoft Healthcare, Shenyang, China). CT scans were obtained with a section thickness of 1 mm, with the CT contrast agent being iophorol comprising an iodine content of 350 mg/mL. The CEUS results were compared with those of CECT imaging, operative findings, and the clinical course, and the manifestations of CEUS images of active bleeding were recorded and analyzed.

All procedures performed in this study were conducted in accordance with the ethical standards of the institutional and/or national research committee(s) and with the Declaration of Helsinki (as revised in 2013). Among the 11 patients, written informed consent was obtained from the three patients for publication of this article and accompanying images, but not obtained from the other eight patients after all possible attempts were made. A copy of the written consent is available for review by the editorial office of this journal.

Results

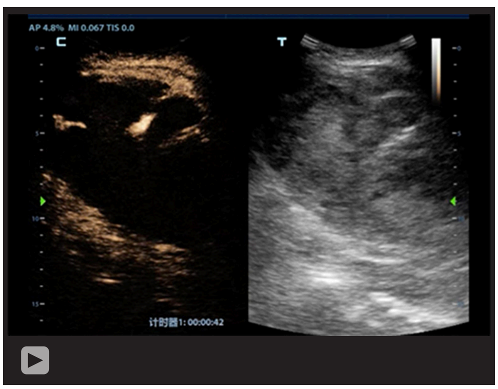
Patient characteristics

During the study period, we identified 11 patients with soft-tissue hematoma. Eleven patients had superficial masses palpated by themselves or medical staff, and the local pain at the mass site was obvious. Laboratory tests showed that hemoglobin decreased to varying degrees, and so bedside ultrasound examination was performed, which confirmed the presence of hematoma. The 11 patients included 5 men and 6 women, aged 46–90 years, with an average age of 67.8 years. Seven of them were on anticoagulation therapy and four had just undergone surgery. The distribution of the hematomas were as follows: 4 (36%) were in the rectus sheath, 3 (27%) in the chest wall, 2 (18%) in the iliopsoas muscle, and 2 (18%) in the lower limb. One patient had hematomas in multiple locations (chest wall and iliopsoas muscle) but mainly in the chest wall. The patient characteristics are summarized in *Table 1*.

Diagnostic results

Seven patients had CEUS results suggesting active bleeding, four of whom had surgery to confirm the presence of active bleeding; meanwhile, the remaining three patients had different degrees of decrease in hemoglobin in the short-term. However, their vital signs were stable without

Figure 1 A 46-year-old woman on long-term oral anticoagulants after aortic and mitral valve replacement was admitted with abdominal pain and was found to have an abdominal wall hematoma. (A) Bedside CEUS showed jet-like enhancement at the edges of the hematoma toward the interior of the hematoma, and active bleeding was considered (white arrows). Contrast arrival was first noted at 10 seconds. (B) CT showed a massive hematoma in the soft tissue, with contrast extravasation in the axial section during the arterial phase (white arrow), which confirmed the diagnostic result of CEUS. CEUS, contrast-enhanced ultrasound; CT, computed tomography.



Video 1 CEUS showed jet-like enhancement at the edges of the hematoma toward the interior of the hematoma, and active bleeding was considered. CEUS, contrast-enhanced ultrasound.

hemorrhagic shock, and hemoglobin levels improved after ultrasound-guided thromboplastin injection treatment or compression hemostasis. Of these seven patients, four underwent CECT examination, which suggested active bleeding in two of these patients. The positive rate of CEUS diagnosis of active bleeding (4/4, 100%) was higher than that of CECT (2/4, 50%) in these four cases, and the diagnostic accuracy of CEUS was highly consistent with the surgical and clinical manifestations. The seven patients diagnosed with active bleeding on CEUS showed jet-like enhancement (2/7; *Figure 1*, *Video 1*), fine-linear enhancement (3/7; *Figure 2*), and an accumulation of contrast microbubbles at the edge (2/7; *Figure 3*). Multiple contrast manifestations could be present in the same case of active hemorrhage. Meanwhile, the remaining four patients had a negative CEUS result showing no significant enhancement that was consistent with their clinical course. The details are presented in *Table 2*.

Discussion

Rapid bedside ultrasonography is becoming increasingly popular among emergency physicians. Ultrasonography can detect hematomas and identify their size and location; however, it is not suitable for deep anatomical sites and certain patient morphotypes (e.g., the iliopsoas muscle in obese patients) and has difficulties in determining the presence of active bleeding. Color Doppler ultrasound can help detect blood flow abnormalities, but may fail when the vascular bleeding is thin or the blood flow velocity is low. CEUS currently plays an important role in the accurate identification of active bleeding (9-11). The ultrasound echo signal is enhanced using contrast microbubbles. The diameter of the contrast microbubble is approximately 2.5 µm, which is smaller than that of red blood cells and can therefore be used to detect microcirculatory perfusion (12). In our study, two patients with jet-like manifestations showed a persistent trend of decreasing hemoglobin and decreasing blood pressure in a short period of time, which was later confirmed to be an arterial rupture

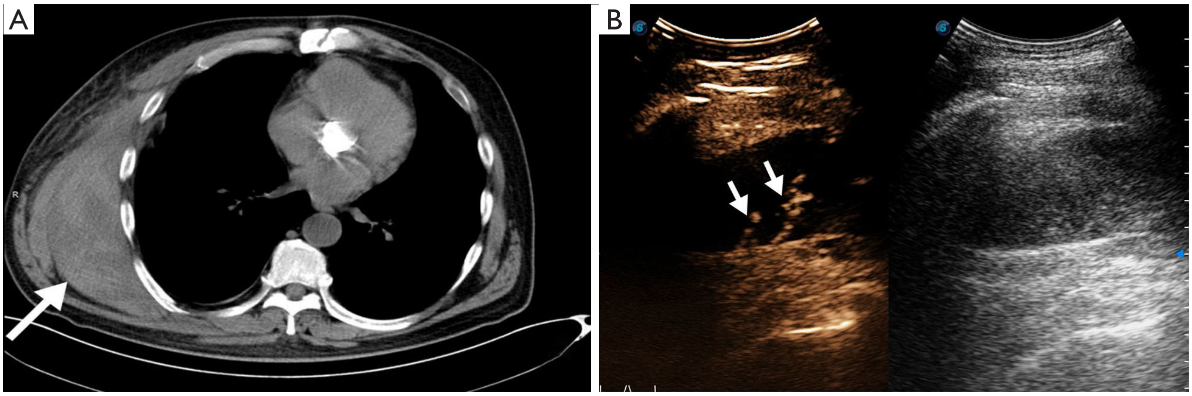


Figure 2 A 68-year-old man on long-term oral anticoagulants after aortic valve replacement was admitted with bruising and swelling of the right back and was found to have a right chest wall hematoma. (A) CT showed a hematoma on the right chest wall (white arrow). (B) Bedside CEUS showed fine-linear enhancement at the edges of the hematoma toward the interior of the hematoma, suggesting active bleeding (white arrows). Contrast arrival was first noted at 13 seconds. CT, computed tomography; CEUS, contrast-enhanced ultrasound.

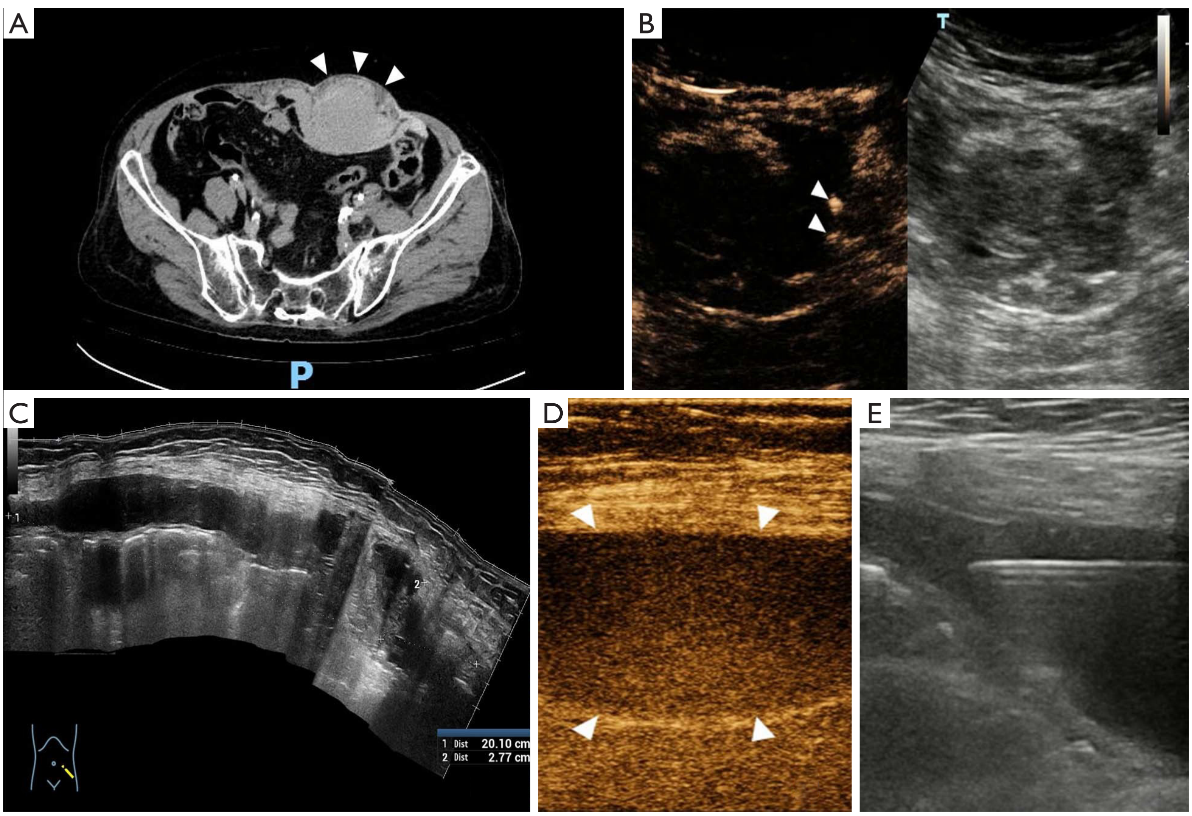


Figure 3 An 82-year-old woman with left abdominal pain 2 hours after stenting for left lower extremity atherosclerotic occlusion was found to have a left subrectus abdominis hematoma. (A) CT showed a subrectus abdominis hematoma (white arrows). (B) Bedside CEUS showed contrast microbubbles accumulating at the edges of the hematoma (white arrows). Contrast arrival was first noted at 20 seconds. (C) Review of US showed a 20.10×2.77 cm hematoma after 10 days of conservative treatment, which was smaller than observed previously. (D) Review of CEUS showed no significant enhancement at the edges of the hematoma (white arrows) after 10 days. (E) The patient underwent ultrasound-guided drainage of the hematoma by puncture placement. P, posterior; CT, computed tomography; CEUS, contrast-enhanced ultrasound; US, ultrasound.

Table 2 Diagnosis and clinical management of soft-tissue hematomas

CEUS imaging features	Active bleeding on CEUS (7 cases)			No active bleeding on CEUS (4 cases) (no significant enhancement of perimeter and interior)
	Jet-like enhancement (2 cases)	Fine-linear enhancement (3 cases)	Contrast microbubbles accumulate at the edge (2 cases)	
Clinical manifestation				
Decrease in hemoglobin compared with baseline	40–50%	<30%	<20%	Less than 10% of the base
Signs of shock	Yes	No	No	No
Bleeding on CECT	Yes	Not done	No	Not done
Ultrasonic characteristics				
Hematoma detected	Yes	Yes	Yes	Yes
Active bleeding detected	No	No	No	No
Clinical treatment	Surgery	Surgery (2 cases); prothrombin injection guided by ultrasound (1 case)	Compression; hemostatic drugs	Compression to stop bleeding; ultrasound-guided percutaneous aspiration (2 cases)

CEUS, contrast-enhanced ultrasound; CECT, contrast-enhanced computed tomography.

in surgery. The intraoperative vessels were about 0.5-cm thick and continued to eject blood into the hematoma. Finally, the hemoglobin levels of the two patients gradually increased after hematoma removal. The other three cases showed multiple linear enhancements of the hematoma after conservative treatment, and the hemoglobin levels continued to decline. Surgery confirmed that the hematoma wall had multiple small arterial leaks with diameters of approximately 0.2 cm. Contrast microbubbles accumulating at the edge were present in seven patients, and the active bleeding and CEUS manifestations in these patients were considered to be related to fine arterial leakage or venous breakage. Only two patients showed only contrast microbubble accumulation at the edge. After pressure bandaging treatment, the hematomas in these two patients became smaller. As a hematoma may have more than one active bleeding site and a changing bleeding rate, we found that different CEUS manifestations could be present in the same case of active hemorrhage. We speculated that the different manifestations of CEUS were related to the flow velocity and inner diameter of the damaged blood vessels. Unfortunately, due to the retrospective nature of the study design, we did not find relevant data on the velocity of bleeding vessels. We simply used contrast arrival time to distinguish arterial from venous bleeding. The other four cases of soft-tissue hematoma were deemed to have no active bleeding, CEUS demonstrated no significant contrast infiltration or spillage in or around the hematoma. Hematomas in two patients were reduced to varying degrees after conservative treatment according to ultrasound. Two other patients underwent ultrasound-guided aspiration of hematoma after a period of conservative treatment, and CEUS follow-up demonstrated a reduction in the nonenhanced area. The management of hematomas depends on patients' clinical symptoms and the presence of active bleeding. Treatment options include conservative treatment, transarterial embolization, ultrasound-guided aspiration of hematomas, and surgery (13-15). The observations from the case series suggest that patients with CEUS showing jet-like enhancement have the greatest risk of hemorrhagic shock and need early surgical intervention.

Compared with CECT, CEUS has the advantages of real-time dynamics, rapid diagnosis, and no nephrotoxicity, and it is especially suitable for patients with critical conditions who should not be transported. Moreover, for patients with identified lesions undergoing conservative treatment, CEUS can effectively reduce the number of follow-up examinations, making them more convenient and safer.

Due to the retrospective nature of our investigation and the small number of patients we included, confirmation of our findings in a broader patient population is required.

In the future, we will collect more data on the velocity of bleeding vessels for further study. CEUS for soft-tissue hematomas in patients with suspected active bleeding is a simple, rapid, and economically convenient diagnostic method. The degree of bleeding may be further estimated according to the manifestations of contrast agent spillage, thus providing an imaging basis for determining whether a soft-tissue hematoma requires timely surgical intervention.

Conclusions

CEUS is a valuable tool for detecting active bleeding in soft tissues. Certain CEUS manifestations of active hemorrhage may have the potential to indicate the severity of bleeding.

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Footnote

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://qims.amegroups.com/article/view/10.21037/qims-23-1585/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee(s) and with the Declaration of Helsinki (as revised in 2013). Among the 11 patients, written informed consent was obtained from the three patients for publication of this article and accompanying images, but not obtained from the other eight patients after all possible attempts were made. A copy of the written consent is available for review by the editorial office of this journal.

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