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下肢深部静脈血栓症の標準的超音波診断法

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1.　目　的

下肢深部静脈血栓症の超音波診断に関する標準的評価法を作成する.

2.　対　象

検査領域は，下大静脈を含めた下肢静脈系とする（**Fig. 1**）.

3.　超音波機器と検査条件

骨盤部では 3.5 MHz のコンベックス型探触子またはセクタ型探触子を，大腿・膝窩・下腿部では 7－10 MHz のリニア型探触子または 3.5－5.0 MHz のコンベックス型探触子を主に使用する．形態診断では B モード法を，血流診断ではカラードプラ法あるいはパルスドプラ法を用いる．カラードプラ法では，折り返しの出現する速度を低流速（10－20 cm/s 程度）に設定する.

4.　超音波診断の検査体位と検査手技

通常は仰臥位で検査するが，静脈拡張が得られる検査体位を工夫する．骨盤・大腿部では仰臥位，膝窩・下腿部では座位または腹臥位とする.

検査は，安静時および負荷を与えて評価する．負荷法として，静脈圧迫法と血流誘発法とがある（**Table 1**）.

安静時評価（**Fig. 2**）：対象静脈を短軸（横断）像と長軸（縦断）像で描出し，壁と内腔を観察する．静脈径については，対側の静脈あるいは同名動脈と比較し，拡張の有無を評価する.

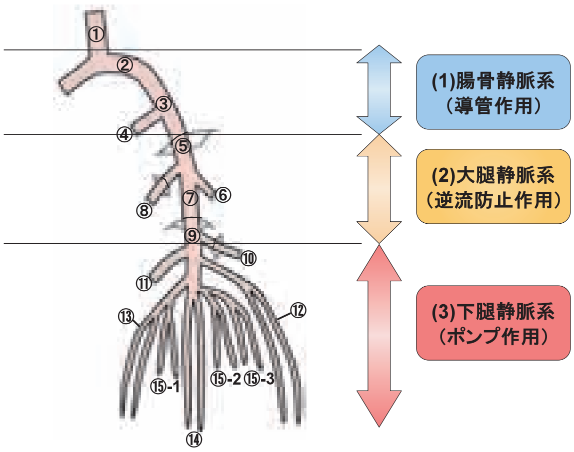

Fig. 1　骨盤・下肢深部静脈系の解剖生理．骨盤・下肢静脈系は生理機能により，（1）導管作用の腸骨静脈系，（2）逆流防止作用の大腿静脈系，（3）ポンプ作用の下腿静脈系の 3 つに区分される．下腿静脈系では，静脈筋ポンプ作用の中心は，ひらめ筋内のひらめ静脈であり通常は，内側枝，中央枝，外側枝の 3 分枝が確認できる．①下大静脈，②総腸骨静脈，③外腸骨静脈，④内腸骨静脈，⑤総大腿静脈，⑥深大腿静脈，⑦浅大腿静脈，⑧大伏在静脈，⑨膝窩静脈，⑩小伏在静脈，⑪腓腹静脈，⑫前脛骨静脈，⑬後脛骨静脈，⑭腓骨静脈，⑮ヒラメ静脈：⑮−1　内側枝，⑮−2　中央枝，⑮−3　外側枝.

静脈圧迫法（**Fig. 3, 4**）：探触子で静脈を圧迫し，静脈の圧縮性を判定する.

血流誘発法：呼吸負荷法とミルキング法がある．呼吸負荷法（**Fig. 5**）は深呼吸させ，血流の変動を

Table 1　静脈血栓の超音波所見

		正常	静脈血栓	
			急性期	慢性期
安静時評価	呼吸性変動 大腿動静脈径 静脈径の左右差 静脈内血栓像	有 動脈＞静脈 無 無	無 動脈＜静脈 有 有（低輝度）	無 動脈＜静脈 有 有（高輝度）
静脈圧迫法	静脈非圧縮所見		有（完全）	有（非完全）
血流誘発法 パルスドプラ法による血流増加反応 カラードプラ法による血流欠損所見		良好	不良 有（完全）	不良 有（非完全）

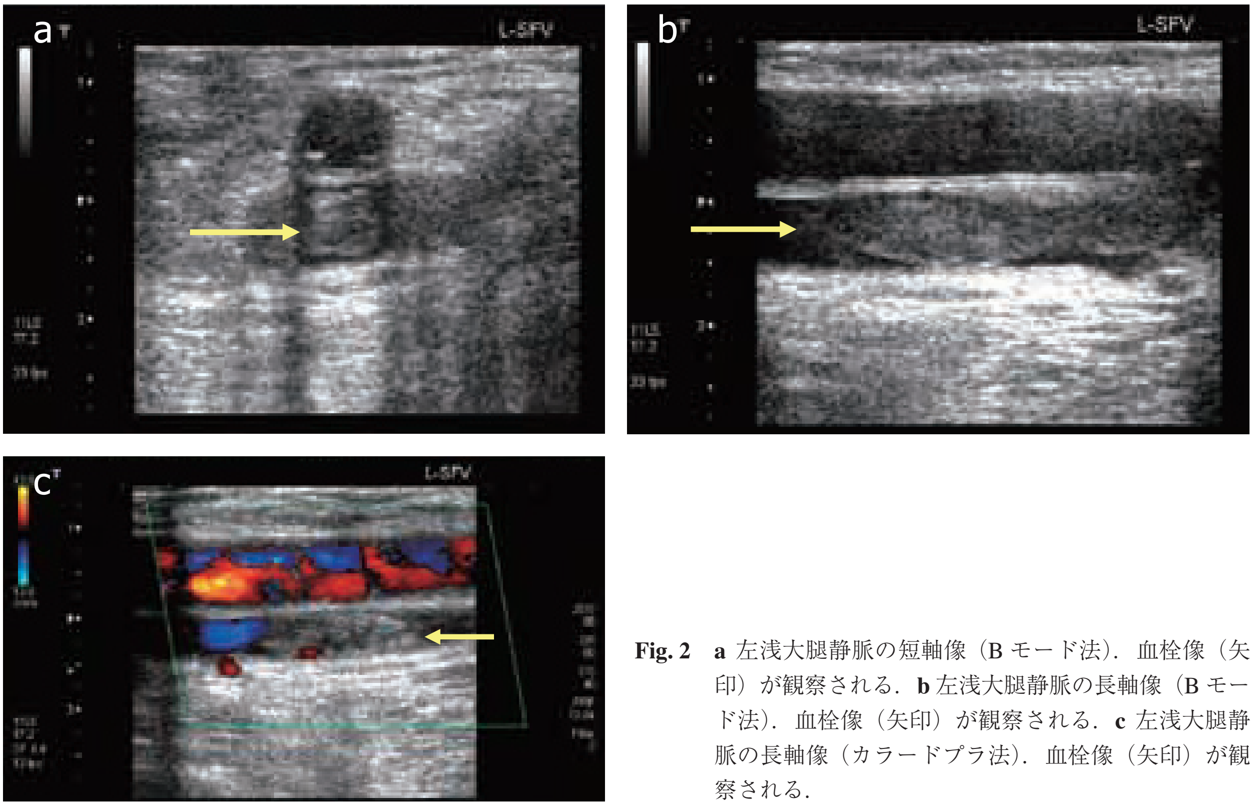

Fig. 2　**a** 左浅大腿静脈の短軸像（B モード法）．血栓像（矢印）が観察される．**b** 左浅大腿静脈の長軸像（B モード法）．血栓像（矢印）が観察される．**c** 左浅大腿静脈の長軸像（カラードプラ法）．血栓像（矢印）が観察される．

観察する．ミルキング法（**Fig. 6**）は，用手的に下腿筋群を圧迫して，中枢側の静脈還流や静脈逆流を判定する．なお，負荷は血栓の存在を考慮し慎重に注意深く行う．

5.　表　示　法

画面表示は，短軸像の描出は足側（末梢側）から見た画面表示とする．長軸像は画面向かって左側を静脈中枢側，右側を静脈末梢側とする．

6.　静脈血栓の診断基準

静脈血栓の超音波所見には，直接所見として静脈内血栓エコーと静脈非圧縮性，間接所見として静脈内血流欠損と誘発法での反応不良所見がある．直接所見を認めれば静脈血栓の確定診断とし，間接所見のみの場合は静脈血栓疑いとする．直接所見を有する場合は，安静時評価，血流誘発法，静脈圧迫法から，総合的に急性期と慢性期を判定する（**Table 1**）．

7.　深部静脈血栓症の超音波診断

深部静脈血栓症の診断には，部位診断（血栓範囲），性状診断（血栓性状），血流診断（還流障害）の検査が必要である．

部位診断：**Fig. 7** に示す手順で大腿静脈系，膝窩

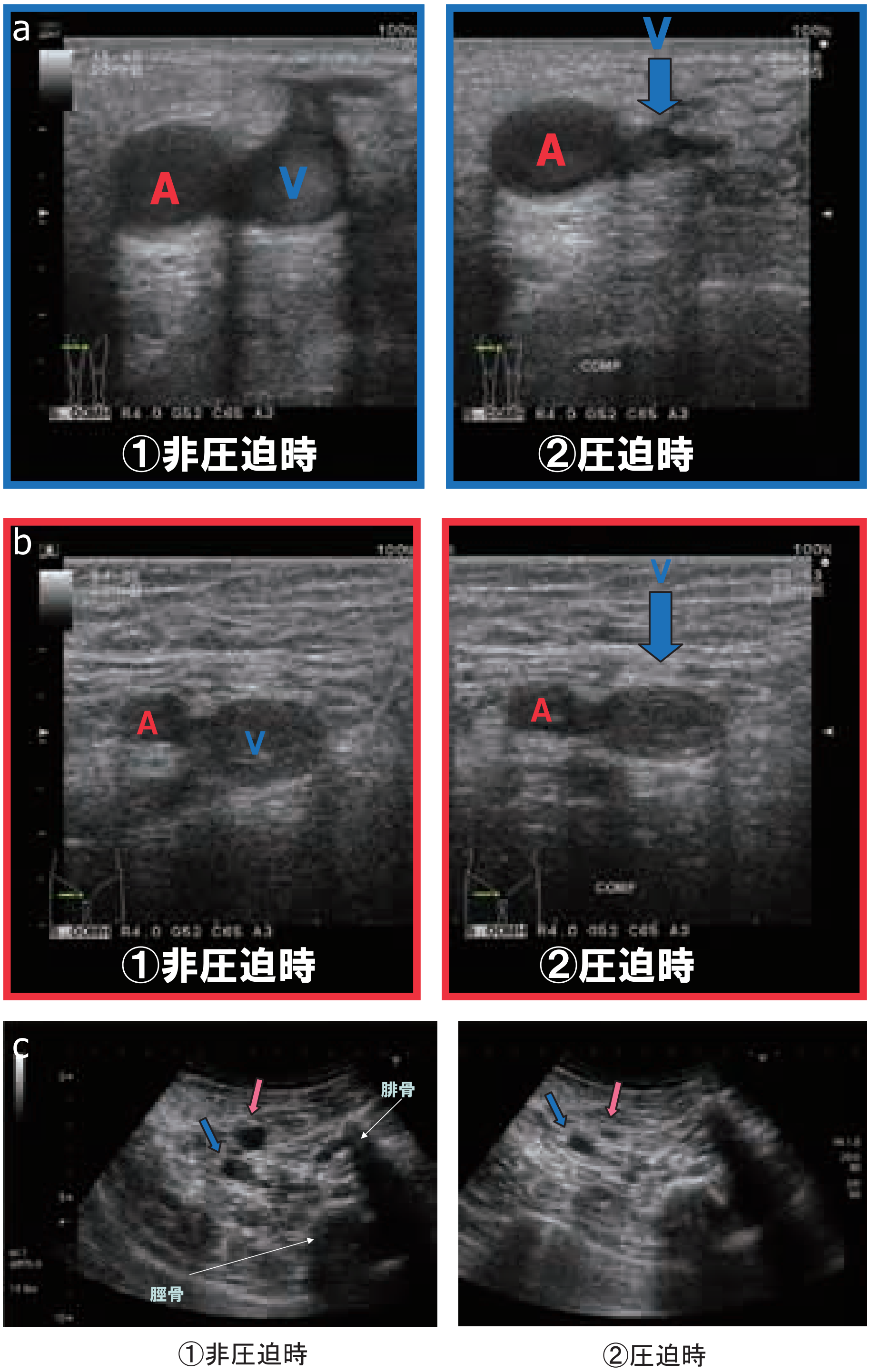

Fig. 3　静脈圧迫法による診断．**a** 健常例の右鼠径部横断像．非圧迫時（左図）に比べ，圧迫時（右図）には，大腿動脈（A）の内側に存在する大腿静脈（V）が圧縮されているのが観察される．**b** 右総大腿静脈血栓症の右鼠径部横断像．圧迫による変形の評価．非圧迫時（左図）には，大腿動脈（A）よりも大腿静脈（V）が太い．圧迫（右図）により，大腿静脈（V）が変形するが，完全には圧縮されない．**c** 右ひらめ静脈内側枝血栓症の右下腿横断像（背側アプローチ）．非圧迫時（左図）には，二本のひらめ静脈（青矢印，赤矢印）が約 1 cm の太さで確認できる．2 本とも血管内のエコーはほぼ無エコーである．圧迫時（右図）には，1 本（赤矢印）は圧縮され，血栓なしと判断するが，あと 1 本（青矢印）は圧縮されず，血栓ありと判断する．

Fig. 4　探触子による静脈圧迫法.

Fig. 6　下腿筋群の用手的圧迫（ミルキング）による静脈血流誘発法.

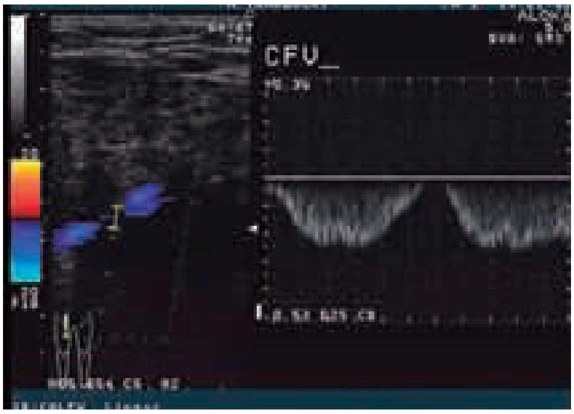

Fig. 5　健常例に見られる総大腿静脈血流の呼吸性変動. 左にサンプルポイント, 右に得られたパルスドプラ法による血流速波形を示す. 吸気時に血流速が低下し, 呼気時に血流速が増加する.

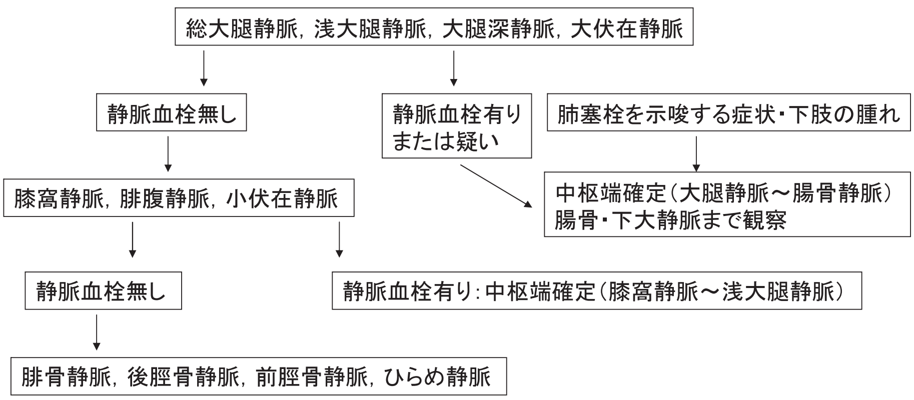

Fig. 7　下肢深部静脈血栓症の検索手順.

静脈系，下腿静脈系，下大静脈・腸骨静脈系の順に検索する．中枢側の静脈（下大静脈，腸骨静脈）は描出が困難な場合もあるが，下肢浮腫が著明な時は特に詳細に観察する．静脈血栓の診断が得られたら，血栓部位および中枢端と末梢端から血栓範囲を確定する．

性状診断：静脈血栓の固定性（浮遊性），経時変化（退縮，器質化，石灰化）を判定する．また，静脈炎の合併も評価する．

慢性期の深部静脈血栓症では，静脈逆流により，静脈弁不全の有無を評価する．

文　献

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Criteria for ultrasound diagnosis of deep venous thrombosis of lower extremities

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1. Objectives

The criteria for ultrasound diagnosis of deep venous thrombosis of the lower extremities are defined.

2. Target

The area to be tested comprises the veins of the lower extremities, including the inferior vena cava (**Fig. 1**).

3. Ultrasound devices and testing conditions

When testing the pelvic region, a 3.5-MHz convex probe or sector probe is primarily used. For testing the femoral, popliteal, and crural areas, a 7- to 10-MHz linear probe or a 3.5- to 5.0-MHz convex probe is primarily used. B-mode ultrasonography is adopted for morphological diagnosis. Color Doppler or pulse Doppler methods are employed for evaluation of blood flow. With the color Doppler method, the velocity scale is set low to 10-20 cm/s.

4. Postures and techniques for ultrasound diagnosis

The test is usually performed in the supine position. As needed, the posture is modified appropriately to al-

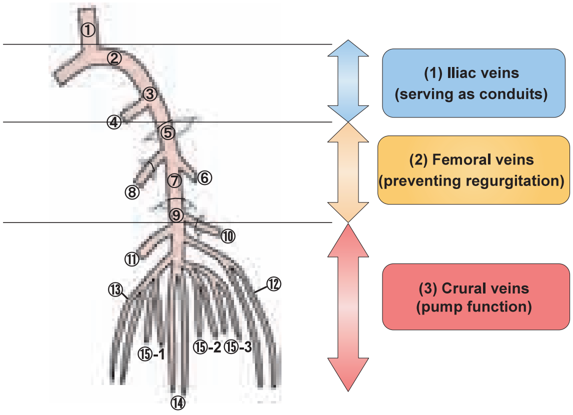

Fig. 1 Anatomy and physiology of deep veins of the pelvis and lower extremities. Veins of the pelvis and lower extremities can be divided into three groups: iliac veins serving as conduits, femoral veins that prevent regurgitation, and crural veins serving as pumps. In the crural veins, the pump function of venous muscle is primarily seen in the soleus vein within the soleus muscle. Three branches (medial, middle, and lateral) of this vein are usually visible. *1*, inferior vena cava; *2*, common iliac vein; *3*, external iliac vein; *4*, internal iliac vein; *5*, common femoral artery; *6*, deep femoral artery; *7*, superficial femoral artery; *8*, great saphenous vein; *9*, popliteal vein; *10*, small saphenous vein; *11*, calf vein; *12*, anterior tibial vein; 13, posterior tibial vein; 14, fibular vein; *15*, soleus vein (*15-1*, medial branch; *15-2*, middle branch; *15-3*, lateral branch)

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Table 1 Ultrasound features of venous thrombosis

	Normal	Venous thrombosis	
		Acute	Chronic
Evaluation at rest			
Respiration-caused fluctuation	Present	Absent	Absent
Diameter of femoral artery/vein ratio	Artery > vein	Artery < vein	Artery < vein
Laterality in venous diameter	Absent	Present	Present
Thrombus-associated echoes inside the vein	Absent	Present (low density)	Present (high density)
Venous compression			
Noncompressibility of the vein		Visible (complete)	Visible (incomplete)
Blood flow induction			
Increased blood flow detected by pulse Doppler study	Good	Poor	Poor
Blood flow defects in vein revealed by color Doppler study		Visible (complete)	Visible (incomplete)

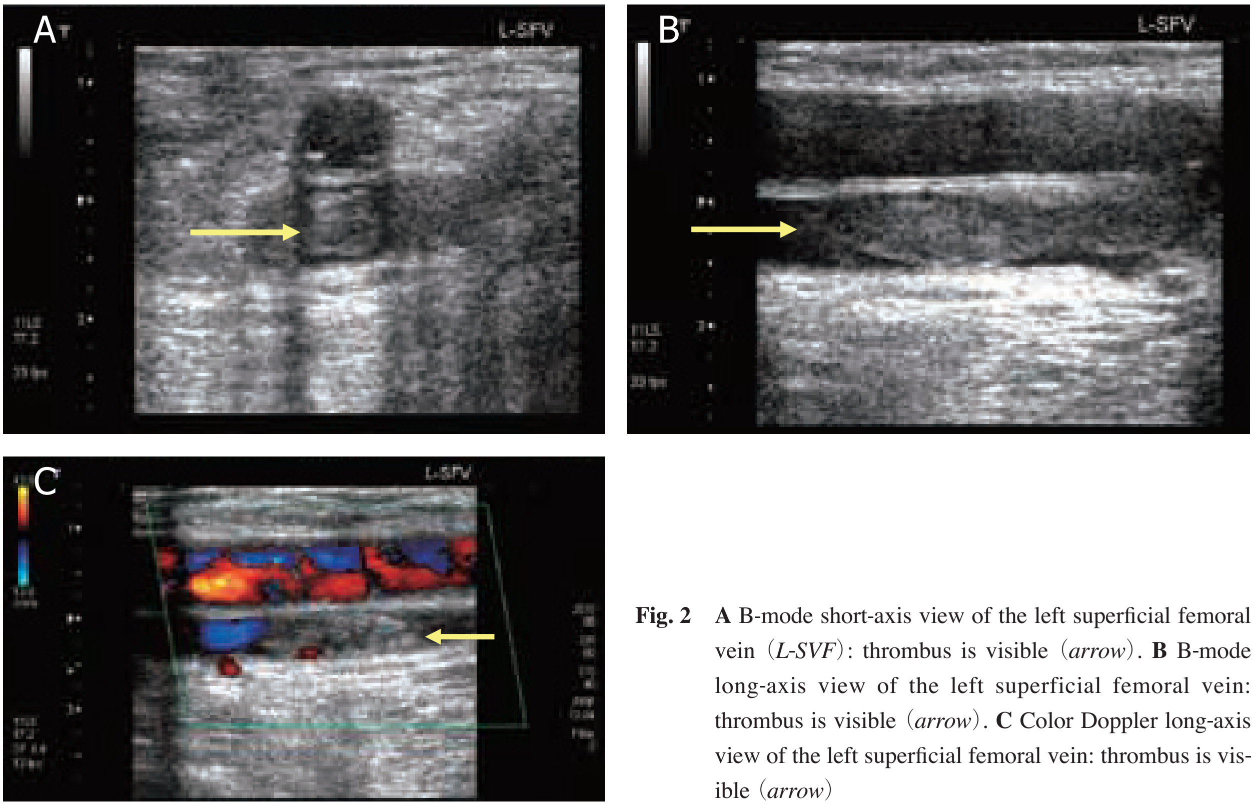

Fig. 2 **A** B-mode short-axis view of the left superficial femoral vein (*L-SVF*): thrombus is visible (*arrow*). **B** B-mode long-axis view of the left superficial femoral vein: thrombus is visible (*arrow*). **C** Color Doppler long-axis view of the left superficial femoral vein: thrombus is visible (*arrow*)

low venous dilation. In the pelvic and femoral areas, the test is conducted in the supine position; in the popliteal and crural areas, the test is conducted in the sitting or prone position.

The test is performed either at rest or with load. The test with load employs either the venous compression method or the blood flow induction method (**Table 1**). A short-axis (cross-sectional) view and a long-axis (longitudinal) view of the target vein are usually taken to check the venous wall and the inside region (**Fig. 2**). The diameter of the target vein is compared with that of the contralateral vein or the homonymous artery to check for dilation of the target vein. With the venous compression method, the skin over the vein is compressed by the probe to evaluate compressibility of the target vein (**Fig. 3, 4**). The blood flow induction method can be subdivided into the respiratory load method and the milking method. With the respiratory

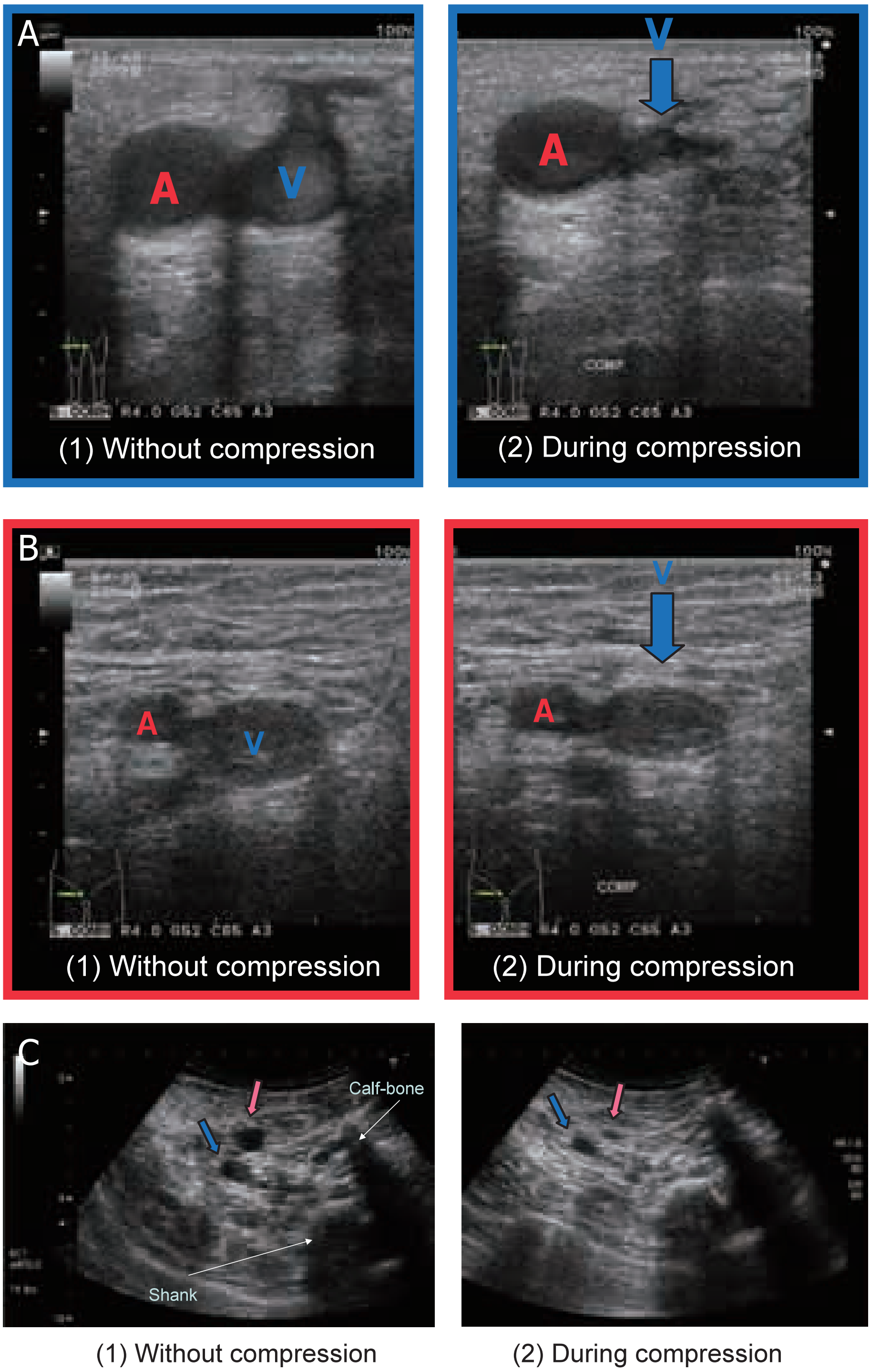

Fig. 3 **A** Cross-sectional view of the right inguinal area in a healthy volunteer. Evaluation of compression-caused deformation. *Left*, without compression, the femoral vein（*V*）, located medial to the femoral artery（*A*）, is visible. *Right*, with compression: under pressure by the probe, the femoral vein appears compressed（*arrow*）. **B** Cross-sectional view of the right inguinal area in a patient with deep venous thrombosis（affecting the right common femoral vein）. Evaluation of compression-caused deformation. *Left*, without compression, the femoral vein（*V*）is thicker than the femoral artery（*A*）. *Right*, with compression: the femoral vein（*V*）is deformed but does not show complete compression. **C** Evaluation of soleus vein thrombosis by the compression method（cross-sectional view of right crus using a dorsal approach）. There is a lesion in the medial branch of the right soleus vein. *Left*, without compression, two soleus veins（*blue* and *red arrows*）are visible, with a thickness of about 1 cm. Both veins are almost free of internal echo. *Right*, when pressure is applied, one of the two veins is compressed（*red arrow*）. This vein is rated as free of thrombus. The other vein is not compressed（*blue arrow*）and is rated as having thrombus

Fig. 4 Evaluation of venous compressibility by the venous compression method

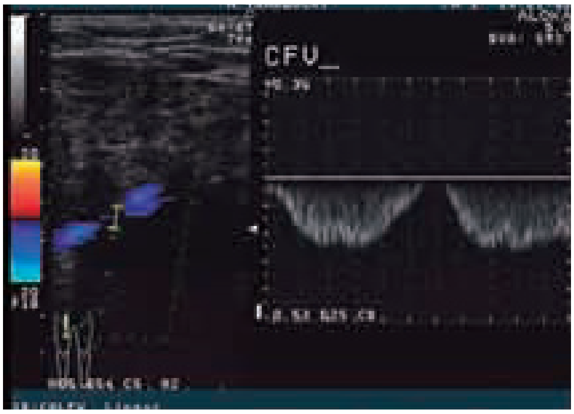

Fig. 5 Respiration-related changes in blood flow through the common femoral vein (*CFV*). *Left*, sampling points for the pulse Doppler method. *Right*, flow velocity pattern using the pulse Doppler method. The flow velocity decreases during inspiration and increases during expiration

load method, changes in blood flow during deep breathing are checked (**Fig. 5**). With the milking method, the crural legs are compressed manually to check for venous return and regurgitation (**Fig. 6**). Loading needs to be done carefully, with the possible presence of thrombi borne in mind.

5. Representation

On the short-axis view, the veins are viewed from the foot side (the distal side). On the long-axis view, the proximal side of the veins is depicted on the left and the distal side on the right.

Fig. 6 Venous blood flow induction method with manual compression (milking) of crural muscles

6. Criteria for diagnosis of venous thrombosis

Direct ultrasound signs of venous thrombosis are thrombotic echoes in veins and lack of venous compressibility. Indirect signs are blood flow defects in the vein and poor responses to the induction method (**Table 1**). The finding of a direct sign allows a definite diagnosis of venous thrombosis. Individuals having only indirect signs are rated as being suspected of having venous thrombosis. Those patients having direct thrombosis signs are rated as acute or chronic based on a general assessment of findings from the tests at rest, with the blood flow induction method, and with the venous compression method.

7. Ultrasound diagnosis of deep venous thrombosis

For making a diagnosis of deep venous thrombosis, it is necessary to evaluate the site (extent of thrombosis), properties (features of thrombus), and blood flow (disturbance in perfusion). The site of thrombosis is checked by the steps shown in **Fig. 7**. Proximal veins (inferior vena cava, iliac vein) are sometimes difficult to depict, but these veins need to be checked carefully in cases where marked leg edema is noted. Veins of the lower extremities are checked in the order of femoral veins, popliteal veins, and crural veins.

After a diagnosis of venous thrombosis has been made, the affected area and the extent of thrombosis

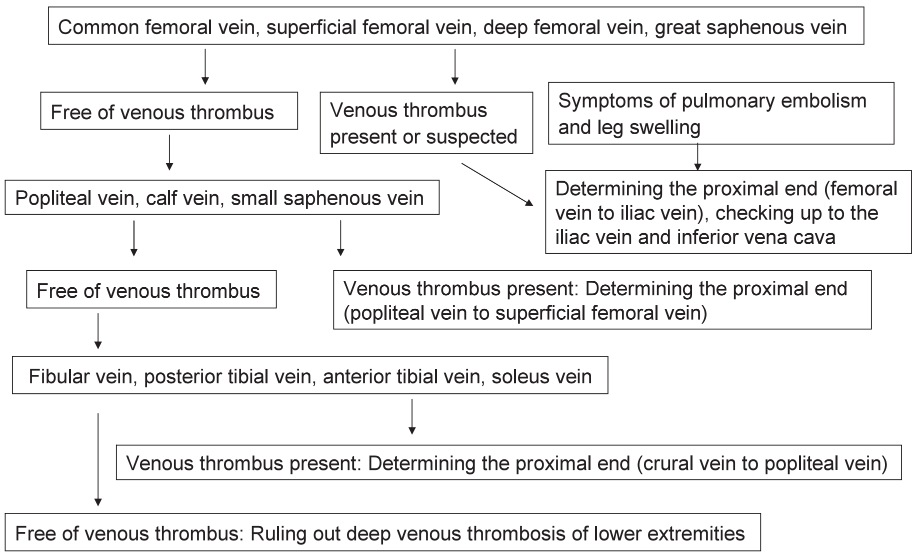

Fig. 7 Steps to explore deep venous thrombosis of lower extremities

(proximal and distal ends) are identified. Evaluation is made of the properties of the thrombus, i.e., the components of the thrombus, immobility (floating nature), and time-related changes (size reduction, organic change, calcification). In cases of chronic deep venous thrombosis, venous valve insufficiency is evaluated by checking for venous regurgitation.

Reference

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