The echocolor Doppler in the diagnosis of the deep vein thrombosis of the lower limbs

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THE ECHOCOLOR DOPPLER IN THE DIAGNOSIS OF THE DEEP VEIN THROMBOSIS.

INTRODUCTION

The deep vein thrombosis (DVT) of the lower limbs is an important cause of mortality and morbidity. The clinically suspected DVT should always be confirmed by instrumental procedures: about 70% of patients with clinically suspected DVT are negative on instrumental investigations. The echocolor Doppler (ECD) is the standard test for diagnosing clinically suspected DVT. The ECD diagnosis of DVT is based on non compressibility of the vein and color/pulsed Doppler provides further information by evaluating blood flow.

Two possible diagnostic strategies are possible:

1. simple compression ultrasound (s-CUS): CUS of the common femoral and popliteal veins
2. complete echocolor Doppler study (complete study of the inferior vena cava, iliac veins, and lower limbs veins, with morphologic and functional assessment), or complete CUS (c-CUS of the proximal and distal veins)
75% of the patients with clinically suspected DVT have normal findings on CUS limited to the common femoral vein in the groin and the popliteal vein.


The clinically suspected deep vein thrombosis should always be confirmed by instrumental procedures.
the echocolor Doppler is the standard test for diagnosing clinically suspected DVT
ULTRASOUND STUDY OF THE VEINS OF THE LOWER LIMBS

The echocolor Doppler is the first-line imaging examination for deep venous thrombosis because of:

1. absence of irradiation and low cost
2. its relative ease of use
3. high sensitivity and specificity

in institutions with experienced sonographers
VEINS OF THE LOWER LIMBS
US diagnostic strategies

ULTRASOUND STUDY OF THE VEINS OF THE LOWER LIMBS
two diagnostic strategies are possible:

1. simple compression ultrasound (s-CUS): CUS of the common femoral and popliteal veins

2. complete echocolor Doppler study (complete ultrasound investigation of the caval, iliac, and lower limbs veins, with morphologic and functional assessment), or complete CUS (c-CUS of the proximal and distal veins)
ULTRASOUND DIAGNOSTIC STRATEGIES:

1. simple CUS (s-CUS)

2. complete echocolor Doppler study/complete CUS (c-CUS)
CUS

- using the transducer, apply direct pressure to completely compress the veins
- veins are compressible and can be collapsed temporarily by applying pressure
- CUS diagnosis of DVT is based on non compressibility of the vein
- if the vein compresses completely, a DVT at this site can be ruled out
s-CUS (SIMPLE CUS)

- transverse compression of:
  1. the common femoral vein and
  2. the popliteal vein
- with a 5-10-MHz transducer
S-CUS OF THE COMMON FEMORAL VEIN

- the common femoral vein is medial to the common femoral artery (located just inferior to the inguinal ligament)
- complete compression of the vein rules out a DVT, whereas the inability to completely compress the vein rules in a DVT
CUS

- Veins are highly compressible and can be collapsed temporarily by applying pressure to them.

CUS of the common femoral vein

a) Before CUS: the common femoral vein and artery are visible
b) CUS: compressibility of the CF vein (the vein that does not have no echogenic material collapses completely). Only the artery is visible.

CUS OF THE COMMON FEMORAL VEIN

a) Before CUS: the common femoral vein and artery are visible
b) CUS: compressibility of the CF vein (the vein that does not have no echogenic material collapses completely). Only the artery is visible.
s-CUS OF THE POPLITEAL VEIN

- the popliteal vein is usually posterior to the popliteal artery (the vein appears closer to the transducer than the artery)
- the popliteal vein is compressed easily (a direct pressure completely compresses the vein).
- complete compression of the vein rules out a DVT
CUS
- veins are highly compressible and can be collapsed temporarily by applying pressure to them

CUS of the popliteal vein

CUS OF THE POPLITEAL VEIN

a) before CUS: the popliteal vein and artery are visible. The popliteal vein is posterior to the popliteal artery (the vein appears closer to the transducer than the artery)

b) CUS: only the popliteal artery is visible. The complete compression of the popliteal vein rules out a DVT
s-CUS (SIMPLE CUS):

- simple, non-invasive, inexpensive, repeatable test
- main diagnostic criterion for the diagnosis of proximal DVT
  but
- not conclusive because a negative result requires that the examination be repeated 7 days later to exclude distal DVT, missed by the initial scan, that extend proximally
ULTRASOUND DIAGNOSTIC STRATEGIES:

1. simple CUS (s-CUS)
2. complete echocolor Doppler study/complete CUS (c-CUS)
COMPLETE ECHOCOLOR DOPPLER STUDY/c-CUS

Alternative to s-CUS are:

1. the complete echocolor Doppler study (venous complete study of the lower limbs and of the inferior vena cava and the iliac veins, with morphologic and functional assessment in longitudinal and transverse scans)

2. the complete compression ultrasonography (c-CUS) of the veins of the lower limbs (from calf to the groin in the axial plane)
1. VENOUS COMPLETE ECHOCOLOR DOPPLER STUDY

- direct visualization of the inferior vena cava, the iliac veins and the veins of lower limbs (with a convex transducer and a 5-10 MHz transducer. Longitudinal and/or transverse scans)

  **color examination**

- depicts the inferior vena cava, the superficial and deep limb veins (the anatomy, the venous wall, the venous valves)

  **Doppler examination**

- assesses the direction, velocity, and pattern of blood flow. The characteristic venous pattern shows a phasic respiratory ventilation with increased flow during expiration and augmentation of flow with calf compression
2. COMPLETE CUS (c-CUS)

- US compression ultrasonography (transverse scans) of the proximal and distal veins of the lower limbs with a 5-10 MHz transducer (or convex transducer in the presence of a big leg)
- compression is applied to induce the complete collapse of the patent vein.
- if the vein does not compress, it is occluded.
COMPLETE CUS (c-CUS)

It is possible to study with CUS the whole venous network of the lower limbs (5-10 MHz transducer or convex transducer in the presence of big leg):

i. the external iliac vein

ii. the femoral veins (common, profundus and superficial)

iii. the popliteal vein

iv. the calf veins
COMPLETE ECHOCOLOR DOPPLER STUDY/COMPLETE CUS

How to do: patient position

A. Study of the thigh:

✓ patient supine with external rotation of the thigh

B. Study of the popliteal fossa:

✓ patient supine with the knee bent, or
✓ patient prone with leg slightly flexed, or
✓ patient sitting with his feet on the knee of the examiner
In the normal subject, the venous flow:

- is unidirectional
- is modulated by the breath
- stops at the Valsalva maneuver
- increases after the compression of the distal veins
COMPLETE ECHOCOLOR DOPPLER STUDY

COMPLETE ECD STUDY

- from inferior vena cava to distal veins
- morphologic and functional assessment (longitudinal and transverse scans)
- the characteristic of the venous flow and the valvular continence are studied

COMPLETE ECD STUDY

common femoral vein:

a) morphologic assessment (longitudinal scan): common femoral vein and origin of the superficial and deep femoral vein
b) functional assessment: characteristic femoral vein pattern (phasic respiratory ventilation with increased flow during expiration)
COMPLETE ECHOCOLOR DOPPLER STUDY

COMPLETE ECD STUDY

- morphologic and functional assessment (longitudinal and transverse scans)
- the characteristic of the venous flow and the valvular continence are studied

**common femoral vein:**

a) functional assessment (longitudinal and transverse scan): characteristic femoral vein pattern (phasic respiratory ventilation with increased flow during expiration)

b) functional assessment: disappearance of the characteristic spontaneous flow when the abdomen is compressed
COMPLETE ECHOCOLOR DOPPLER STUDY

COMPLETE ECD STUDY
- morphologic and functional assessment (longitudinal and transverse scans)
- the characteristic of the venous flow and the valvular continence are studied

a)

b)

COMPLETE ECHOCOLOR DOPPLER STUDY
popliteal vein:
a) morphologic assessment (longitudinal and transverse scan): popliteal vein and artery
b) functional assessment: appropriate increased popliteal flow when the lower extremity is compressed, without reflux
The examination should include the deep calf veins:

1. the posterior tibial veins
2. the peroneal veins
3. the anterior tibial veins (this vein is rarely affected by the thrombotic process)
4. soleal and gastrocnemius intramuscular veins

All these venous segments are investigated over their entire length (longitudinal and transverse scans, with morphologic and functional assessment) using different incidences: anterior medial, posterior and posterior lateral.
DEEP DISTAL VEINS
anatomic considerations

The term "distal" means "below the knee".

The deep distal vein are:

1. the deep calf veins (the peroneal veins, the posterior and anterior tibial veins)
2. the calf muscle veins (gastrocnemius and the soleus muscle veins)
DEEP VEIN THROMBOSIS
ultrasound diagnosis

ULTRASOUND DIAGNOSIS OF DVT

ACUTE PHASE

1. CUS (s-CUS)
2. complete echocolor Doppler study/c-CUS

CHRONIC PHASE

1. CUS (s-CUS)
2. complete echocolor Doppler study/c-CUS
ULTRASOUND DIAGNOSIS OF DVT

ACUTE PHASE

1. CUS (s-CUS)

2. complete echocolor Doppler study/c-CUS

CHRONIC PHASE

1. CUS (s-CUS)

2. complete echocolor Doppler study/c-CUS
SIMPLE CUS (s-CUS):

- s-CUS: compression of the proximal veins (femoral and popliteal veins)
- the diagnosis of DVT is based on non compressibility of the vein: it is a simple maneuver but not conclusive (it does not allow to diagnose distal DVT)
- high accuracy and sensitivity for the diagnosis of symptomatic proximal DVT
**DEEP VEIN THROMBOSIS s-CUS**

- **s-CUS diagnosis of DVT** is based on noncompressibility of the vein.
- If DVT is present: a) it is impossible to collapse the vein; b) echogenic material fills the venous lumen; c) no color

**CUS of the common femoral vein**

- a) Lt CFV: open
- b) rt CFV: not compressible due to DVT

**s-CUS: DVT OF THE RT. COMMON FEMORAL VEIN**
- a) Lt. CFV: open; b) the thrombosed rt. CFV does not compress. DVT is visualized as hypoechoic
s-CUS diagnosis of DVT is based on noncompressibility of the vein.
- if DVT is present: a) it is impossible to collapse the vein; b) echogenic material fills the venous lumen; c) no color

s-CUS: DVT NOT COMPLETELY OCCLUDING THE POPLITEAL VEIN
a) echogenic material (blood clot) which partially fills the venous lumen
b) CUS: the DVT diagnosis is based on not complete compressibility of the vein
s-CUS diagnosis of DVT is based on noncompressibility of the vein. If DVT is present: a) it is impossible to collapse the vein; b) echogenic material fills the venous lumen; c) no color.

s-CUS in popliteal DVT: examples

a) Not occluding:
   a) CUS: presence of echoes within the vascular lumen; the popliteal vein in axial scan is not completely compressible

b) Occluding:
   b) CUS: popliteal vein is not compressible due to the presence of thrombus completely occluding
SIMPLE CUS (s-CUS):

- it is a simple maneuver but not conclusive (it does not allow to diagnose distal DVT)
- a negative result requires that the examination be repeated 7 days later to exclude distal DVT, missed by the initial scan, that extend proximally

_Cogo A et al. Implications for simplifying the diagnostic process with compression ultrasound. Arch Intern Med 1993_

DEEP VEIN THROMBOSIS
ultrasound diagnosis

ULTRASOUND DIAGNOSIS OF DVT

ACUTE PHASE

1. CUS (s-CUS)

2. complete echocolor Doppler study/c-CUS

CHRONIC PHASE

1. CUS (s-CUS)

2. complete echocolor Doppler study/c-CUS
DEEP VEIN THROMBOSIS
complete echocolor Doppler study

COMPLETE ECHOCOLOR DOPPLER STUDY
The US findings in acute DVT include:

1. B mode: presence of echoes within the vascular lumen (the vein is not compressible)
2. color Doppler: area with absence of color. Collateral vessels are depicted
3. Doppler flow:
   i. absent or abnormal flow
   ii. loss of appropriate increased flow when the lower extremity is compressed implies occlusion (DVT) between the transducer and the compressed area
DEEP VEIN THROMBOSIS

NATURAL HISTORY: THE VENOUS THROMBUS IN ACUTE PHASE

1. the thrombus originates behind the valve
2. the thrombus becomes "floating"
3. the thrombus attaches to the wall and fills the venous lumen

DVT: ACUTE PHASE

- the thrombus originates behind the valve and grows in the center of the vein
DEEP VEIN THROMBOSIS
complete echocolor Doppler study

COMPLETE VENOUS US INVESTIGATION

- it is possible to study the thrombus and its development
- the majority of venous thrombi originates within the valve cusps of the deep veins, usually distal

complete venous US investigation:
examples of distal DVT, in development

- venous thrombi that originate from two valve cusps of two intramuscular gastrocnemius veins
DEEP VEIN THROMBOSIS
complete echocolor Doppler study

the complete venous US investigation
is a valid tool for initial diagnosis of DVT

The DVT usually starts in the deep veins of the calf, often originating in the valve cusps

Kakkar VV et al. Natural history of postoperative deep-vein thrombosis. Lancet 1969
DEEP VEIN THROMBOSIS
complete echocolor Doppler study

COMPLETE VENOUS US INVESTIGATION
- it is possible a detailed examination from the vena cava to the distal veins
- in longitudinal scans it is possible to evaluate the presence of thrombus, its characteristics (size, mobility ....)

a) V IL EST DX

complete venous US investigation:
iliac and inferior vena cava DVT
- iliac DVT (lumen occluded by thrombus)
- the DVT is extended into the inferior vena cava (mobile thrombus)
DEEP VEIN THROMBOSIS complete echocolor Doppler study

**complete venous US investigation**
- it is possible a detailed examination from the vena cava to the distal veins, with morphologic and functional assessment in longitudinal and transverse scans

**complete venous US investigation in retrograde DVT (a).**
A) Inferior vena cava DVT (in vena cava filter):
DVT of the IVC (in vena cava filter) in longitudinal (a) and transverse (b) scans
complete venous US investigation

- it is possible a detailed examination from the vena cava to the distal veins, with morphologic and functional assessment in longitudinal and transverse scans

complete venous US investigation in retrograde DVT (b).

B) Same patient. Inferior vena cava DVT (in vena cava filter):
The DVT of the IVC is extended in the rt. femoro-popliteal veins (a); and lt. common and superficial femoral veins (b). No DVT in lt. popliteal vein (c), with loss of appropriate increased flow when the lower extremity is compressed
DEEP VEIN THROMBOSIS

COMPLETE VENOUS US INVESTIGATION

- Longitudinal scans: to evaluate the presence of thrombus, its characteristics (size, mobility ....)
- Transverse scans: to evaluate the compressibility of the veins
- Doppler: to evaluate the presence of flow and its characteristics

**complete venous US investigation: DVT of the common femoral vein**

a) Longitudinal scan: DVT of the common femoral vein. The external iliac vein and the saphenous vein are patent. The flow of the saphenous vein is continuous, compensatory.
b) Transverse scan: common femoral vein lumen almost completely filled by thrombus.
DEEP VEIN THROMBOSIS
complete echocolor Doppler study

COMPLETE VENOUS US INVESTIGATION

- it is possible to visualize directly the distal end of the thrombus and to evaluate its characteristics (when floating is at high risk for embolism)

complete venous US investigation: floating thrombi

- longitudinal scans: a), b) floating thrombi in common femoral veins; c) floating thrombus in popliteal vein
DEEP VEIN THROMBOSIS
complete echocolor Doppler study

COMPLETE VENOUS US INVESTIGATION

- it is possible to visualize directly the distal end of the DVT, to evaluate the extent and the characteristics of the thrombus

complete venous US investigation:
study the characteristics and extent of the thrombus

- examples of DVT with the head of the thrombus "cut off", due to the flow from collateral veins
DEEP VEIN THROMBOSIS
complete echocolor Doppler study

COMPLETE VENOUS US INVESTIGATION
- it is possible the morphological and hemodynamic study to evaluate the characteristics of the thrombus and of the flow

complete venous US investigation
study the characteristics and extent of the thrombus
1. color Doppler: area with absence of color is visualized (popliteal DVT)
2. abnormal Doppler flow: loss of appropriate increased flow, when the lower extremity is compressed
DEEP VEIN THROMBOSIS
complete echocolor Doppler study

COMPLETE VENOUS US INVESTIGATION
- it is possible to visualize directly the distal end of the thrombus and to evaluate its characteristics (when floating is at high risk for embolism)

complete venous US investigation:
floating thrombus
- longitudinal scans with linear (a) and convex probes (b): popliteal thrombus (distal end, floating, in superficial femoral vein)
DEEP VEIN THROMBOSIS complete echocolor Doppler study

COMPLETE VENOUS US INVESTIGATION

- is possible to evaluate the presence of a thrombus and its characteristics (size and extension)

superficial femoral vein DVT
longitudinal and transverse scan: DVT localized in a short segment

superficial femoral vein DVT
color and B mode: local DVT

complete venous US investigation
in DVT localized in a short segment of the vein

- examples of local DVT of two superficial femoral veins
DEEP VEIN THROMBOSIS
complete echocolor Doppler study

COMPLETE VENOUS US INVESTIGATION
- it is possible to evaluate the presence of a thrombus and its characteristics (size and extension)
- it is possible to study the distal veins with longitudinal and transverse scan

complete venous US investigation in gastrocnemius DVT not completely occluding the lumen
a) longitudinal scan (color and B mode): presence of echoes within the vascular lumen
b) transverse scan: the vein is not is not completely compressible (0,16 cm.)
DEEP VEIN THROMBOSIS
complete echocolor Doppler study

COMPLETE VENOUS US INVESTIGATION

- it is possible to evaluate the presence of a thrombus and its characteristics (size and extension)
- it is possible to study the distal veins with longitudinal and transverse scan

complete venous US investigation in perforating vein and posterior tibial veins DVT

- progressive thrombosis of perforating veins extending into the deep venous system (longitudinal and transverse scans)
DEEP VEIN THROMBOSIS
complete echocolor Doppler study

COMPLETE ECHOCOLOR DOPPLER STUDY
1. it is possible to evaluate the collateral vessels

complete venous US investigation in popliteal DVT

a) absence of color and presence of echoes within the vascular lumen of the popliteal vein
b) collateral vessels are depicted
DEEP VEIN THROMBOSIS
complete echocolor Doppler study

COMPLETE VENOUS US INVESTIGATION

- it is possible to visualize directly the distal end of the DVT, to evaluate the extent and the characteristics of the thrombus

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**complete venous US investigation: popliteal DVT**

a, b) longitudinal and transverse scans of the popliteal DVT. It is possible to visualize directly the distal end (c) of the DVT: the origin of the posterior and anterior tibial veins are open.

d, e) the distal posterior tibial veins are open (longitud. and transverse scans)
DEEP VEIN THROMBOSIS
complete echocolor Doppler study

COMPLETE VENOUS US INVESTIGATION

- it is possible to visualize directly the distal end of the DVT, to evaluate the extent and the characteristics of the thrombus

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complete venous US investigation:
gastrocnemius DVT and control after heparin therapy

a) acute phase: longitudinal scan of the gastrocnemius DVT (complete occlusion). It is possible to visualize directly the distal end of the DVT. The popliteal vein is open.
b) control 8 days later: longitudinal and transverse scans. Partial recanalization of the gastrocnemius DVT, but popliteal extension of the DVT.
COMPLETE CUS (c-CUS)

- compression of the whole venous network of the lower limbs (proximal veins and distal veins)
- the diagnosis of DVT is based on non compressibility of the vein
- the CUS diagnosis of isolated distal DVT diagnosis is more operator-dependent and less sensitive than the proximal vein ultrasound examination
DEEP VEIN THROMBOSIS c-CUS

**complete CUS (c-CUS)**
It is possible to study with CUS the whole venous network of the lower limbs (proximal veins and distal veins)

**complete CUS in anterograde DVT:**
DVT from posterior tibial veins extended in gastrocnemius vein, in popliteal vein, in superficial and common femoral vein. The end of the thrombus is mobile, in the common femoral vein.
complete CUS (c-CUS)

It is possible to study with CUS the whole venous network of the lower limbs (proximal veins and distal veins)

c-CUS in superficial femoral DVT

- transverse view in superficial femoral vein duplication (congenital variant): DVT of only one superficial femoral vein
Distal deep vein thrombosis: anatomical considerations

Even if anatomy does not solve this nomenclature problem, the following terms should be used in clinical practice:

1. Isolated calf muscle vein thrombosis (ICMVT) is a thrombosis confined to the muscle veins only.
2. Deep calf vein thrombosis (DCVT) is a thrombosis present in the paired calf veins.
3. Isolated distal deep vein thrombosis (IDDVT) is the composite of ICMVT and DCVT – occurring either in isolation or in combination

*Isolated distal deep vein thrombosis: what we know and what we are doing. G. PALARETI and S. SCHELLONG. J Thromb Haemost 2012*
DEEP DISTAL VEINS
anatomic considerations

ISOLATED DISTAL DEEP VEIN THROMBOSIS.
DVT below the knee of:

1. the deep calf veins
   i. the peroneal veins
   ii. the posterior veins
   iii. the anterior tibial veins

2. the calf muscle veins
   i. the gastrocnemius veins
   ii. the soleus muscle veins
complete CUS (c-CUS)

- it is possible to study with CUS the whole venous network of the lower limbs (proximal veins and distal veins)
- the CUS diagnosis of isolated distal DVT diagnosis is more operator-dependent and less sensitive than the proximal vein ultrasound examination

c-CUS in isolated calf muscle vein thrombosis

- isolated thrombosis of gastrocnemius veins: the veins are not compressible and absence of color
**DEEP VEIN THROMBOSIS**
c-CUS

**complete CUS (c-CUS)**
- it is possible to study with CUS the whole venous network of the lower limbs (proximal veins and distal veins)
- the CUS diagnosis of isolated distal DVT diagnosis is more operator-dependent and less sensitive than the proximal vein ultrasound examination

**c-CUS in isolated calf muscle vein thrombosis**

a) transverse scan: isolated thrombosis of gastrocnemius vein not completely occluding
b) transverse scan (CUS): the vein is not completely compressible (CUS = 0,15 cm.)
complete CUS (c-CUS)

- it is possible to study with CUS the whole venous network of the lower limbs (proximal veins and distal veins)
- the CUS diagnosis of isolated distal DVT diagnosis is more operator-dependent and less sensitive than the proximal vein ultrasound examination

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c-CUS in deep calf vein thrombosis

- thrombosis of the posterior tibial veins: the veins are not compressible and absence of color
complete venous US investigation/c-CUS in isolated distal DVT:

The ultrasound diagnosis of the below-the-knee thrombus is:

i. more operator-dependent

ii. less sensitive

than proximal vein ultrasound examination
DVT AND SINGLE COMPLETE ECHOCOLOR DOPPLER STUDY/c-CUS
A diagnostic strategy validated? Hypothesis 1

COMPLETE ECHOCOLOR DOPPLER STUDY OF THE LOWER LIMBS AND OF THE CAVAL ILIAC DISTRICT:
As it is a diagnostic strategy not as validated as the others, it is recommendable in vascular diagnostic centers that have highly expert operators; the anterior tibial veins can be excluded from the study as they are not subject to isolated thrombosis.

*Guidelines GIUV. International angiology 2012*
A single complete ultrasound investigation of the venous network for the diagnostic management of patients with a clinically suspected first episode of deep venous thrombosis of the lower limbs

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Summary
In patients clinically suspected of deep-vein thrombosis (DVT) of the lower limbs, it is safe to withhold anticoagulant therapy after a negative ultrasound (US) limited to the popliteal and the femoral veins, provided that this can either be repeated or results. The main outcome measure was the occurrence of objectively documented clinical thromboembolic events during a three-month follow-up after a negative US.

Out of 623 patients, 401 (64.4%) had a baseline negative US,

In conclusion, it is safe to withhold anticoagulant therapy in patients with clinically suspected DVT after a single, negative, complete US. Integrating this method within diagnostic strategies for DVT could improve management and be more acceptable for patients and physicians.

Thromb Haemost 2003; 89: 221-7
ULTRASOUND DIAGNOSIS OF DVT

ACUTE PHASE

1. CUS (s-CUS)
2. complete echocolor Doppler study/c-CUS

CHRONIC PHASE

1. CUS (s-CUS)
2. complete echocolor Doppler study/c-CUS
DEEP VEIN THROMBOSIS

NATURAL HISTORY OF VENOUS THROMBUS: CHRONIC PHASE

i. the thrombus retracts, recanalization of the vein
ii. the thrombus: a) may be completely reabsorbed; b) may leave a 'scar'; c) may remain occluding (smaller percentage)

DVT: CHRONIC PHASE

- the venous thrombus retracts, recanalization of the vein. The vessel wall are thicker than normal.
# Deep Vein Thrombosis

## DVT: US Features in Acute Phase and in Chronic Phase (Outcomes)

<table>
<thead>
<tr>
<th>DVT: Acute Phase</th>
<th>DVT: Chronic Phase</th>
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<tbody>
<tr>
<td>Thrombus: smooth margins</td>
<td>Thrombus: irregular margins</td>
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<tr>
<td>Floating thrombus</td>
<td>Thrombus on the edge of the vein wall</td>
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<tr>
<td>Dilation of the vein, not compressible</td>
<td>Normal vein, or small</td>
</tr>
<tr>
<td>Thrombus: mainly hypoechoic</td>
<td>Thrombus: mainly hyperechoic</td>
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</table>
CUS is a valid tool also for assessment of the long-term outcome of the DVT

CUS in the chronic phase of the DVT

- often, in the chronic phase of the DVT are present residual thrombosis
- CUS evaluation of the residual thrombus is important for prognostic and diagnostic purposes (the residual thrombus is a risk factor for recurrent DVT and is useful in the diagnosis of DVT relapse)
RESIDUAL VENOUS THROMBOSIS

Ultrasonographic assessment of the common femoral and popliteal veins was performed 3 months after acute DVT in all patients and at 6, 12, 24, and 36 months in patients found to have residual venous thrombosis. Veins were considered recanalized if they were 2.0 mm or less in diameter on a single test or 3.0 mm or less in diameter on two consecutive tests.

RESULTS:

The cumulative incidence of normal results on ultrasonography was 38.8% at 6 months, 58.1% at 12 months, 69.3% at 24 months, and 73.8% at 36 months.

**DEEP VEIN THROMBOSIS**

**c-CUS: chronic phase**

**RESIDUAL VENOUS THROMBOSIS**

- in presence of residual venous thrombosis the venous lumen is not completely compressible

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**CUS: popliteal DVT in acute phase**

a) CUS: noncompressibility of the the popliteal vein (completely occluded)

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**CUS: popliteal DVT control 3 months later**

a) the echogenic material partially fills the popliteal vein. Residual venous thrombosis

b) CUS: incomplete compressibility (0.47 x 1.39 mm.) of the popliteal vein
RESIDUAL VENOUS THROMBOSIS

- in presence of residual venous thrombosis the venous lumen is not completely compressible

CUS: residual venous thrombosis in the popliteal vein

a) transverse scan: echogenic material which partially fills the venous lumen
b) CUS: in presence of residual venous thrombosis the popliteal vein is not completely compressible (0.58 x 0.37 cm.)
RESIDUAL VENOUS THROMBOSIS: CUS

- in presence of residual venous thrombosis the venous lumen is not completely compressible
- CUS evaluation of the residual thrombus is important for:
  i. prognostic purposes (it is a risk factor for recurrent TV)
  ii. diagnostic purposes (it is useful in the diagnosis of relapse)
CUS AND SUSPECTED DVT RECURRENTNESS

- A new DVT can be diagnosed owing to the presence of a new non-compressible venous segment or to the increase of the residual thrombus ≥ 4 mm.
- If the residual thrombus has not increased or if its increase is ≤ 2 mm compared to the previous examination, the presence of proximal recurrence of DVT is ruled out.
- D-dimer can be useful in cases in which the US test is not diagnostic (increase of the residual thrombus between 2 and 4 mm): a negative D-dimer would rule out the recurrence of DVT.

DEEP VEIN THROMBOSIS

DVT recurrence: ultrasound diagnosis

popliteal DVT recurrence

a) longitudinal and tranverse scans: echogenic material in the popliteal vein and incomplete compressibility of the vein (CUS = 0.37 mm.) due to the residual venous thrombosis

b) control one year later (patient with edema of the calf and pain). The residual vein thrombus (CUS = 0.67 mm.) is increased more than 2 mm. compared with the previous ultrasound examination: DVT recurrence
ULTRASOUND DIAGNOSIS OF DVT

ACUTE PHASE

1. CUS (s-CUS)
2. complete echocolor Doppler study/c-CUS

CHRONIC PHASE

1. CUS (s-CUS)
2. complete echocolor Doppler study/c-CUS
The echocolor Doppler is a valid tool also for assessment of the long-term outcome of the DVT

The complete echocolor Doppler study in the chronic phase of the DVT

- CUS evaluation of the residual thrombus is important for prognostic and diagnostic purposes
- The morphologic and hemodynamic study can help, in this phase, the visualization of the lumen recanalized and the evaluation of continence/incontinence of the venous valves
DEEP VEIN THROMBOSIS complete ECD study/c-CUS

The complete echocolor Doppler study in the assessment of the long-term outcome of the DVT

outcome of previous Lt. popliteal-femoral-iliac-IVC DVT
a) the inferior vena cava is patent with regular flow (longitudinal scan: morphologic and functional study); b, c) the injury caused by DVT (residual venous thrombosis) is visualized mainly in the iliac vein and less in the common femoral vein (longitudinal scan: morphologic study); d) in the superficial femoral vein a pathological reflux is visualized (longitudinal scan: functional study)
DEEP VEIN THROMBOSIS complete ECD study/c-CUS

The complete echocolor Doppler study in the assessment of the long-term outcome of the DVT

residual venous thrombosis in the popliteal vein

a) longitudinal scans (color and B mode): echogenic material in the venous lumen

d) Doppler (functional study): in this case we see a pathological reflux
DEEP VEIN THROMBOSIS complete ECD study/c-CUS

The complete echocolor Doppler study in the assessment of the long-term outcome of the DVT

residual venous thrombosis in the popliteal vein

a) longitudinal scans (color and B mode): echogenic material in the venous lumen; b) tranverse scans: echogenic material in the venous lumen
c) CUS: incomplete compressibility of the vein (0.58 x 0.37 mm.) due to the residual venous thrombosis
d) Doppler (functional study): in this case no pathological reflux
The complete echocolor Doppler study in the assessment of the long-term outcome of the DVT

a) longitudinal scan
residual venous thrombosis (hyperechoic) with valvular incontinence

b) transverse scan and CUS
residual venous thrombosis

outcome of previous popliteal DVT

a) longitudinal scan: morphologic and functional study
   i. color: injury caused by DVT (residual venous thrombosis)
   ii. Doppler: pathological reflux is visualized (due to valvular incontinence)

b) transverse scan and CUS: residual venous thrombosis
DEEP VEIN THROMBOSIS complete ECD study/c-CUS

The complete echocolor Doppler study in the assessment of the long-term outcome of the DVT

subsequent control in patients with gastrocnemius DVT (transverse scan)

a) acute phase: two gastrocnemius veins completely occluded
b) control after 40 days: complete recanalization of the DVT
DEEP VEIN THROMBOSIS
complete ECD study/c-CUS

The complete echocolor Doppler study in the assessment of the long-term outcome of the DVT

acute gastrocnemius DVT and subsequent controls (longitudinal scans)

a) acute phase: gastrocnemius vein completely occluded
b), c) controls after 15 days and 40 days: progressive but partial recanalization of the vein (residual, hyperechoic, venous thrombosis)
DEEP VEIN THROMBOSIS
US diagnostic accuracy

US DIAGNOSTIC ACCURACY AND LIMITS IN PATIENTS WITH SUSPECTED DVT
US DIAGNOSTIC ACCURACY IN PTS WITH SUSPECTED DVT (US VS CONTRAST VENOGRAPHY. META-ANALYSIS)

compression US alone

i. sensitivity for proximal DVT = 93.8%
ii. sensitivity for distal DVT = 56.8%
iii. specificity = 97.8%

Steve Goodacre et al. Systematic review and meta-analysis of the diagnostic accuracy of ultrasonography for deep vein thrombosis. BMC Medical Imaging 2005
US diagnostic accuracy in pts with suspected DVT (US vs contrast venography. Meta-analysis)

duplex US
i. sensitivity for proximal DVT = 96.5%
ii. sensitivity for distal DVT = 71.2%
iii. specificity = 94.0%

triplex US
i. sensitivity for proximal DVT = 96.4%
ii. sensitivity for distal DVT = 75.2%
iii. specificity of 94.3%

Steve Goodacre et al. Systematic review and meta-analysis of the diagnostic accuracy of ultrasonography for deep vein thrombosis. BMC Medical Imaging 2005
ECHO COLOR DOPPLER AND DVT

limits

i. iliac or pelvic DVT may be missed because of interposed bowel gas: an iliac or pelvic DVT cannot be often excluded (this is the major limitation of duplex scanning in patients with DVT)

ii. the US diagnosis of the below-the-knee DVT (c-CUS/complete venous US investigation) is more operator-dependent and less sensitive than proximal vein ultrasound examination

iii. a pitfall in diagnosis is possible in the superficial femoral vein duplication (a congenital variant) and in presence of a focal thrombus

iv. visualization at the adductor canal is difficult

v. false-positive findings: chronic DVT can be interpreted as acute DVT

vi. false-negative findings: due to the size of the patient's leg and/or edema

vii. the US quality depends on the experience of the professional performer
COMPLETE ECHOCOLOR DOPPLER STUDY OF THE LOWER LIMBS AND OF THE CAVAL ILIAC DISTRICT:

As it is a diagnostic strategy not as validated as the others, it is recommendable in vascular diagnostic centers that have highly expert operators; the anterior tibial veins can be excluded from the study as they are not subject to isolated thrombosis.

Guidelines GIUV. International angiology 2012
DEEP VEIN THROMBOSIS
US pitfalls

pitfall

A pitfall in diagnosis is possible in presence of a superficial femoral vein duplication (a congenital variant).

pitfall in superficial femoral vein duplication

- DVT of only one superficial femoral vein: in this case if the congenital variant is not recognized and the patent superficial femoral vein is identified, the DVT may be missed.
DEEP VEIN THROMBOSIS
US pitfalls

**pitfall**
- a focal thrombus may not be identified: it must be made a careful scan of each segment!

**pitfall in presence of focal thrombus**
- this focal thrombus of the superficial femoral vein may not be identified, in particular if it is localized in the adductor canal
DEEP VEIN THROMBOSIS
US pitfalls

pitfall
- in patients with leg edema ambiguous images are possible
- false negative findings are possible for the size of the patient's leg and/or edema

ambiguous images in rt. lymphostasis: transverse scan
a) rt. anterior tibial veins and artery: ambiguous image (edema is present)
b) lt. anterior tibial veins and artery: the veins and the artery are visible
DEEP VEIN THROMBOSIS
US pitfalls

popliteal vein aneurysm: pitfall!

popliteal vein aneurysm that mimic DVT
- popliteal vein aneurysm with smoke-like echo due to blood stasis (condition that mimic DVT!)
- color Doppler: presence of color (no DVT!)
DEEP VEIN THROMBOSIS
US pitfalls

**Pitfall**
- An isolated thrombosis of the anterior tibial vein may not be identified if it is not made a careful scan of each segment (the anterior tibial vein is rarely affected by an isolated thrombosis)

**Rare Case of Isolated DVT of the Anterior Tibial Vein**
- Longitudinal and transverse scan

**Pitfall in Isolated Thrombosis of the Anterior Tibial Vein**
- This isolated thrombosis of the anterior tibial vein thrombus may not be identified
DEEP VEIN THROMBOSIS
US pitfalls

RESIDUAL VEIN THROMBOSIS
AND SUSPECTED DVT RECURRENCE

- pitfalls may result from a technical error in CUS or from interpreting chronic DVT as acute DVT
- however, the CUS with a consideration of venous diameter is highly sensitive in identifying DVT recurrence

short videos and playlists on echocolor Doppler physics are available on
https://www.facebook.com/francoaccorsiecodoppler/ and my youtube channel:
http://www.youtube.com/channel/UCij561sX0bQoEjXIWKuPnKg