Lymphology
Quo Vadis?

Part-2

Lymphatic system
anatomy, physiology and pathology
for MRTs

Imaging of the lymphatic system

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Lymphatic system (LS) awareness amongst Medical Imaging students is low.

Out of the 215 participants in a recent survey, **12.5%** could list 3 to 4 elements of the LS

“I don’t see what the LS has to do with bones and radiography.

“I have never seen any knowledge of the LS been used in the clinical practice”
ELEMENTS OF THE LS

1. Lymph

2. L. vessels:
   - capillaries
   - trunks
   - cisterna chily
   - ducts

   lumbar x 2
   Intestinal x 1
   broncho-mediastinal x 2
   subclavian
   jugular
   thoracic duct
   right lymph duct

3. L. nodes

   popliteal & inguinal
   para iliac & para aortic
   Inf. mes., celiac, sup. mes.
   cubital, axillary
   para sternal
   supra & infraclavicular
   cervical, mastoid

4. L. tissue, and organs

   appendix, Peyer’s patches, tonsils, spleen, thymus
Primary bone marrow lymphoma
1. LYMPH

[Image of two test tubes labeled A and B with fluid samples.]

[Diagram showing the lymphatic system with labels for filtration, reabsorption, and fluid quantities: 20 L, 2 L, 18 L, ca. 10%, ca. 90%.]
Henry Starling (1866-1927) - “Starling equation” for fluid movement across capillary wall and the formation of lymph (Fanous et al. (2007).

30% of lymph is intestinal

>>> fats

50% of lymph is hepatic

>>> proteins
**B lymphocytes - humoral immunity**
- Mature in red bone marrow
- Develop memory for antigens
- Become plasma cells that secrete antibodies
- Attack extracellular antigens

**T lymphocytes - cell immunity**
- Mature in thymus
- Attack intracellular antigens
2. LYMPHATIC VESSELS CAPILLARIES

Start as blind sacks

Capillary wall features:
- endothelial cells
- no muscle layer
- no basement membrane

Prevent collapsing and secure absorption, even in a high-pressure environments

Marieb & Hoehn (2008)
LACTEAL CAPILLARIES IN INTESTINAL MUCOSA

An active peristaltic transporter
- Where is the bone interstitium?
- Do bones have lymphatics?
  - No

Metastasis to bone do not occur via lymphatics

http://histology.medicine.umich.edu/resources/bone-bone-formation#learning-objectives

2. LYMPHATIC DUCTS

Frederik Ruysch (1638 – 1731)

[Diagram showing lymphatic ducts and valves]

Valves

Muscle fibres

http://www.sciencedirect.com/topics/page/Lymph_capillary


3. LYMPHATIC NODES

Average LN: 0.83 gr
Metastatic LN: 2.34 gr

8% of 0.5gr LNS are metastatic

SIZE MATTERS, BUT NOT MUCH

Function:
- filtration of lymph
- lymphocytes B & T reservoir
- immune response

https://www.slideshare.net/AbincDavid/anatomy-of-lymph-node
LYMPH NODES MAP

SUPERFICIAL
- Mastoid
- Inframandibular
- Cervical
- Supraclavicular
- Infraclavicular
- Axillary
- Epitrochlear
- Inguinal
- Popliteal

DEEP
- Para sternal
- Mediastinal
- Celiac
- Superior mesenteric
- Inferior mesenteric
- Para aortic
- Internal iliac

Less suitable for US
SUPERFICIAL LYMPH NODES

Mammography can see them

US can diagnose them

Enlarged hypoechoic malignant LNs in

https://www.sanovadermatology.com/skin-cancer/what-is-a-sentinel-lymph-node-biopsy-and-when-is-it-recommended-for-skin-cancer/

https://www.researchgate.net/figure/221869554_fig4_Fig-5-Lymph-node-and-afferent-lymphatic-vessels-the-ventral-cervical-node-left-and

DEEP LYMPH NODES

Hilar l.n.

Sub-carinal l.n.


4. LYMPH TISSUES AND ORGANS

DIFFUSE LYMPH TISSUE – nodules beneath mucosa and serosa

Peyer’s patches in distal ileum

LYMPHOMA
LYMPH GLANDS

TONSILS & ADENOIDS
LYMPH ORGANS
THYMUS

Thymus compared to thyroid: hypoechoic & heterogeneous
THYMUS

Sail sign

http://learningradiology.com/notes/chestnotes/thymicsailsigns.htm

THYMOMA

https://radiologykey.com/mmediastinum-and-hila/
SPLEEN
SPLENOMEGALY


https://radiopaedia.org/articles/splenomegaly
THE MODERN IMAGING OF LS HAS HISTORY

Paolo Mascagni - (1755-1815) - Italian
Invented dyeing of lymphatics with Mercury
- a precursor of lymphangiography.

Dimitrie Gerota (1867-1939) - the first
Romanian radiologist - introduced the
Prussian blue paint / turpentine / ether mix.

Hernani Monteiro - University of Porto introduced lymphography in 1931

John Kinmonth (1916-1982) - Irish
In 1952, he introduced the contrast lymphangiography
Several valves prior to venous angle

Thoracic duct

Cisterna chily

The technique is invasive and time consuming, but exceptionally accurate.
and exceptionally detailed

**INGUINAL NODES**

The significant variability of number, size, and appearance can simulate malignancy in this region.

CURRENT LYMPHANGIOGRAPHIC TECHNIQUES

Depending on the application of the contrast include:

- **Intra-vascular**
  - cannulation of l. vessels – already presented
  - retrograde veno-lymphatic cannulation
  From subclavian vein to l. ducts

- **Intra-interstitial**

- **Intra-nodal** - US guided administration of:
  - iodinated contrast
  - gadolinium

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http://radiology.rsna.org/content/212/2/598.long
http://ar.iiarjournals.org/content/35/2/891/F3.large.jpg
INTRANODAL LS MRI

- an instant **HIT**
- exceptional presentation of the central LS (11, 12).

Plastic bronchitis

http://pediatrics.aappublications.org/content/134/2/e590
THE CURRENT IMAGING OF LS
IS ALSO A MOLECULAR IMAGING

- *in vivo*
- visualization and measurement
- of dynamic biological processes
- *at molecular and cellular levels*
- by using a radiotracer

It includes: nuclear medicine, MR imaging, MR spectroscopy, optical imaging, US, and others...... (Mankoff DA, JNM 48(6)18N, 2007)

1940s - Hand-held Geiger counters
1950  - Rectilinear scanner of Benedict Cassen
1956  - Photo scanner
1960  - **Gamma camera** (Scintillation camera)
1976  - John Keyes - SPECT (single photon emission *computed tomography*)
        = Gamma camera + rotating detecting system + $^{99m}$Tc + computerising...
1978  - $^{18}$FDG - Ido et al.
2000  - **Fluorescence** imaging - fluorescence agent + light = photons emission
        - Bioluminiscence imaging
        - Cerenkov luminescence imaging
2010s - Raman imaging, photoacoustic imaging, SERS, IVM, OFDI, ADM, SS-R......