

Historical review of lymphatic studies in the head and neck

Wei-Ren Pan, De-Guang Wang

Key words

Head and neck, history, lymph node, lymphatic system, lymph node, lymphoedema.

Wei-Ren Pan is Professor of Anatomy, Department of Human Anatomy, Xuzhou Medical College, Xuzhou, Jiangsu, China. De-Guang Wang is Professor of Anatomy, Department of Human Anatomy, Xuzhou Medical College, Xuzhou, Jiangsu, China.

The lymphatic system plays an important role in immune response and disease, and is an important means of cancer dissemination, yet is one of the least understood aspects of human anatomy. Current text books are largely based on anatomical studies from the 18th and 19th centuries.

Recent clinical experience in melanoma and cadaveric studies have led to a fundamental re-evaluation of our understanding of the lymphatic system previous studies, as the patterns of drainage deviate from what earlier models predict – especially in the head and neck (Uren et al, 1999; Thompson et al, 2004; Pan et al, 2008a).

This review aims to increase awareness of the lymphatic anatomy of the head and neck. Improved understanding should assist in clinical management and further scientific research.

Background

Although the earliest reference to the lymphatic system comes from ancient times, the lymphatic vessels were not identified until early 17th century. In 1622, while in search of nerves, Aselli discovered lacteal vessels in the mesentery while dissecting a well-fed canine. He found that the milk-like liquid flowed freely from

Abstract

The discovery of the lymphatic system occurred later than the other vascular systems. Early studies only observed lymphatics of the viscera in mammals. Lymphatics of the head and neck were not revealed until the mercury injection technique was introduced, which detailed in books of Mascagni (1787) and Sappey (1874) that were largely referred by later literatures. However, the knowledge does not match or explain some of the unexpected clinical findings. This paper reviews the current investigative approaches through the historical perspective for clinical management and scientific researches in this region.

the cut edge of these vessel and recognised that they were related to meals; after repeated dissections in both well-fed and unfed animals, Aselli failed to reveal these vessels in the latter. The details were well described in his book published 4 years after his death in 1627 (Haagensen et al, 1972; Kanter, 1987; Skandalakis, 1995).

Although early anatomists tried to inject water, ink, various coloured liquids, and wax into all types of vessels, it was not until Nuck (1692) introduced the mercury injection technique that it was possible to delineate the lymphatics. Thereafter, this technique became the primary method of investigating the lymphatic system for the next two centuries.

Cruikshank used the mercury injection technique to identify lymphatic vessels and made a composite drawing of the lymphatic vessels and lymph nodes of the whole body (Figure 1). These drawings represented the lymphatic vessels including their structure, number, lymphatic valves and varying arrangements. Cruikshank's book (1786), *The Anatomy of the Absorbing Vessels of the Human Body*, was the first comprehensive anatomical description of the lymphatic system in man and its role in absorption and disease.

Mascagni used a method similar to Cruikshank's to illustrate human lymphatics. In 1787, he published an atlas of the lymphatic system that portrayed the

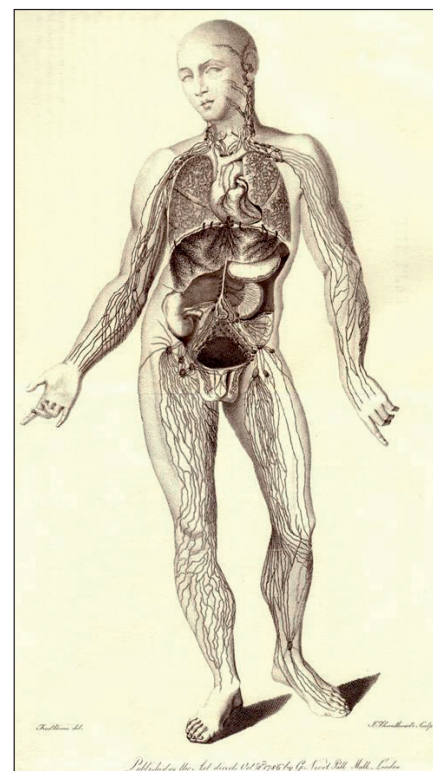


Figure 1. Cruikshank's drawing of the lymphatics in man (1786).

lymphatics of the entire body (Figure 2) and advanced the work of Cruikshank, especially with regards to the head and neck.

During the 19th century Sappey carried out an extensive series of lymphatic studies. His book, *Anatomy, Physiology, Pathology of Lymphatic Vessels*, was published in French in 1874. It was refurbished by Delaware et al (1903) and translated into English by Leaf. This was the first book of drawings that presented the lymphatic network, distribution of the whole body including organs with the structures of the lymph vessels and nodes. Using a fine glass cannula, Sappey injected mercury into the cutaneous lymphatics of the superficial layer of the dermis of putrefied cadavers. His description of the anatomical, physiological, and pathological details of the human lymphatic system have been accepted and applied for more than a

hundred years (Figure 3). However, his drawings were based on multiple cadaver dissections and are composite images.

Beyond the mercury injection technique

Mercury is toxic and vaporises at room temperature. Gerota reported an improved, safer method for the injection and visualisation of the collecting lymph vessels in 1896. He suspended Prussian blue dye in turpentine with ether and injected it into fresh cadaver tissue through a fine glass needle with a small syringe. The Prussian blue dye highlighted the lymphatic vessels that could then be observed in the tissue surrounding the injection point. This technique was dubbed “Gerota’s method”.

In 1909, Bartels use Gerota’s method to assess the lymphatics of cadavers of young children and foetuses and published

Figure 3. Lateral (a) and anterior (b) views of the lymphatics of the head and neck by Sappey (1874).

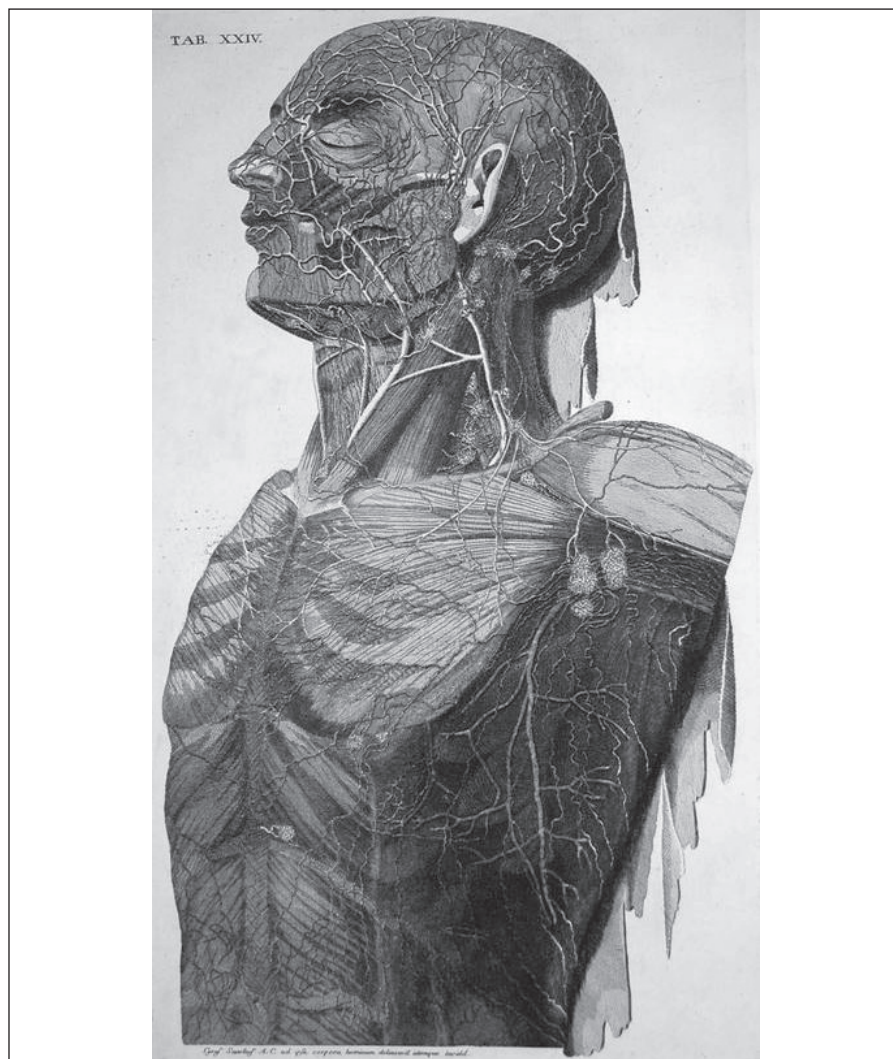
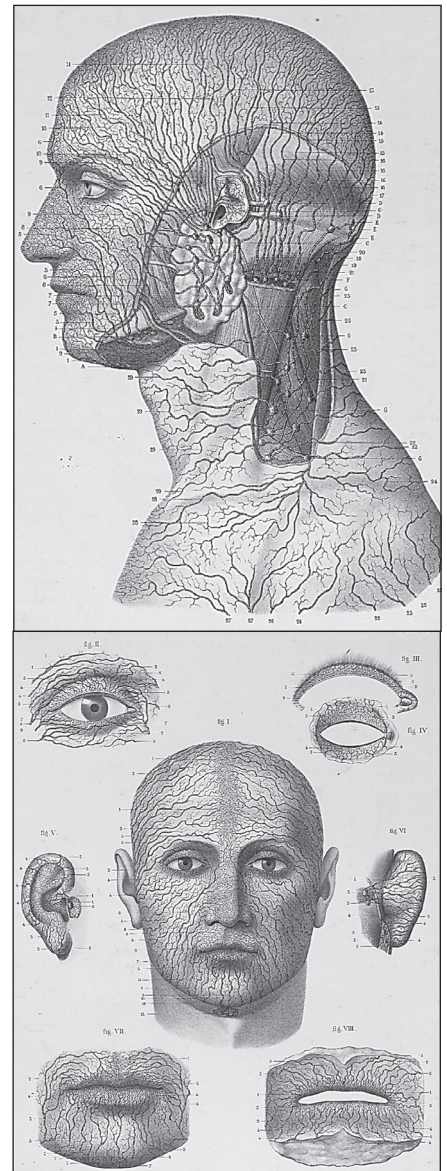
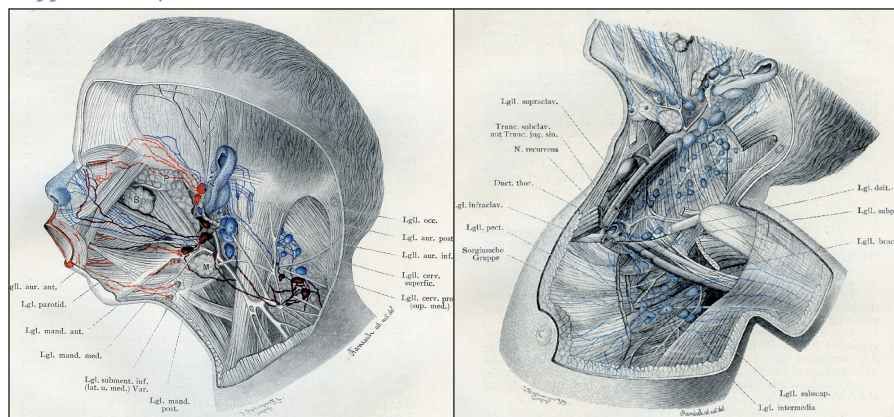


Figure 2. Mascagni’s (1787) drawing of the lymphatics of the head and neck and the anterior upper torso.

an anatomical book of the lymphatic system (Figure 4). Also primarily using Gerota’s methods, Rouvière conducted an exhaustive study of human lymphatic vessels, nodes, and their territories. He conducted a review of the works of others and published his classic book, *Anatomy of the Human Lymphatic System*, in French in 1932. It was translated into English by Tobias in 1938. Rouvière results included the description of lymph nodes distributed around the retropharyngeal wall, which become known as “Rouvière lymph nodes” by later anatomists and physicians (Watanabe et al, 1985).

Figure 4. The results of the study of the lymphatics of the head and neck and anterior upper torso by Bartel in 1909.



The head and neck

Knowledge of the lymphatic system of the head and neck is largely based on early anatomical studies (Mascagni, 1787; Sappy, 1874; Bartels, 1909; Gerota, 1932), but does not explain some of more recent clinical and lymphoscintigraphic findings in cancer patients.

Uren et al (1999) and Thompson et al (2004) reported anomalies in lymphatic drainage patterns with lymphoscintigraphy while managing melanoma that are discordant with our current understanding of the system. A re-appraisal of lymphatic drainage is required to assist surgeons in anticipating lymphatic drainage pathways, and thereby reduce the incidence of false-negative investigations.

In 2005, a new method of lymphatic assessment was published by Suami

et al (2005). The technique uses hydrogen peroxide (Johnson and Blake, 1966) and micro-vascular injection with a lead-oxide mixture (Rees and Taylor, 1986). The results are radiological images and photographs that show in detail the superficial lymphatic vessels within the subcutaneous fascia.

Thereafter the publication of this technique, a series of reports on the lymphatics of the head and neck were published. Including radiographic, photographic, and histopathological data, these studies reported on the lymphatic drainage of the superficial tissues of the head and neck (Pan et al, 2008a), nasal fossae and nasopharynx (Pan et al, 2009), tongue and soft palate (Pan et al, 2010a), external ear (Pan et al, 2011a), the morphology of the human lymphatic vessels in the head and neck (Pan et al. 2010b), variations in

head and neck drainage patterns (Pan et al, 2011b), and senile changes in lymph nodes (Pan et al, 2008b).

A rich lymphatic plexus was found to exist in the dermis, the galea layer of the scalp and the mucous membrane that connect anatomically adjacent lymph territories. The lymph collecting vessels have been found densely in the scalp and the lateral neck; but only sparsely in the face, and anterior and posterior of the neck. Each group of lymphatic vessels has been identified and named, including the previously undescribed complex cervical lymphatic group, revealing a complete lymphatic map of the integument of the head and neck (Figure 5). Lymphatic pathway patterns differ from person to person and are even asymmetrical on each side of the same body (Figure 6).

Perhaps the most important finding from these more recent studies is that lymphatic vessels do not always enter the nearest node, but sometimes bypassed them and drain to different node, even if they come from the same group. For example, the lymphatics of the parietal region may drain into preauricular, retroauricular, infraauricular, or even internal jugular lymph nodes. Therefore, some lymph nodes could be first tier nodes for one group of vessels but second, third, or even fourth tier nodes for the others (Pan et al, 2011b).

Other incidental findings, such as the lymphatic ampulae and diverticula, the translucent lymph nodes, the lymphatic bypass routes, and the lympho-venous shunt, all add to our knowledge of the lymphatic system and impact on the management of lymphoedema and oncology.

Conclusion

Knowledge of the lymphatic anatomy of the head and neck has been advanced by using this new technique. It will help with clinical management and encourage further research.

Acknowledgements

Many thanks to Professor G Ian Taylor, Mr Mark Ashton and Mr Russell Corlett for their invaluable support.

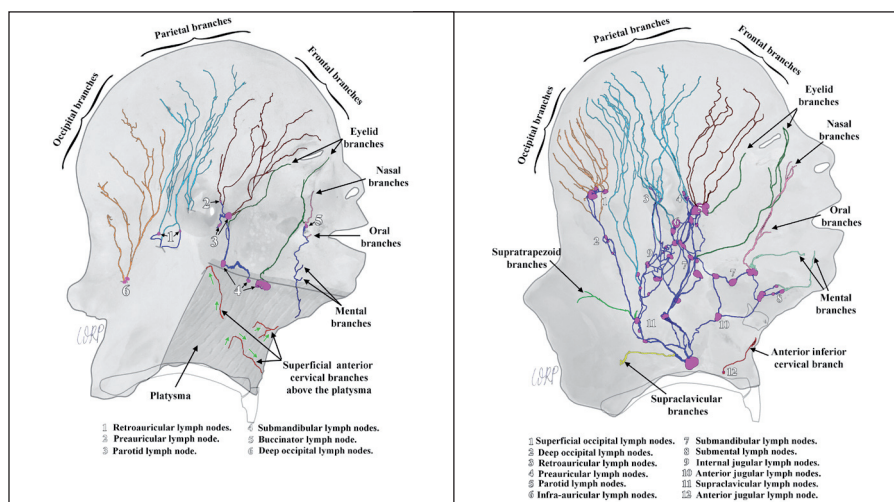
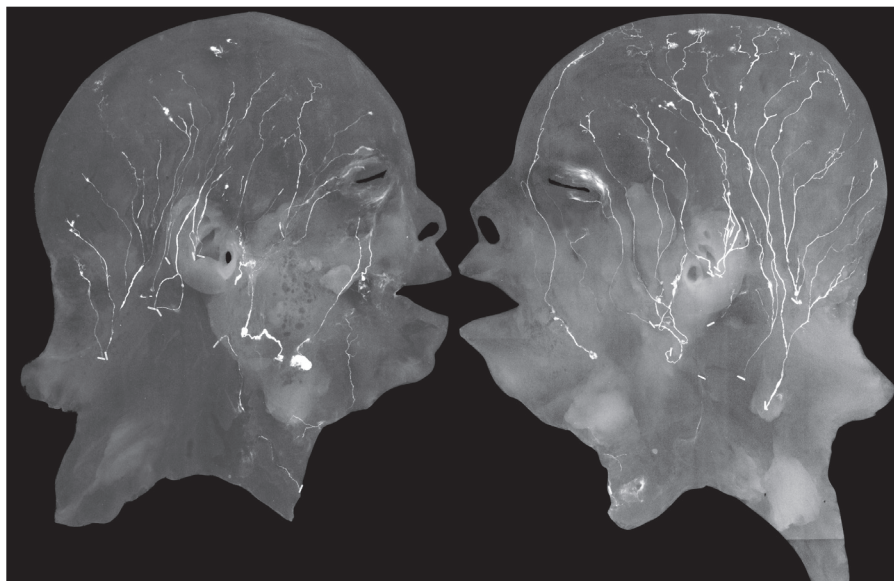


Figure 5. Distribution of lymphatic vessels in the superficial tissue of the head and neck above the platysma. Vessels are colour coded highlighting the different branches and lymph nodes.

Figure 6. A radiograph of the superficial tissues both sides of the head and neck of the same cadaver after lead oxide injection showing the distribution of the lymph vessels and lymph nodes. Note the asymmetrical lymphatic pathway patterns.



References

- Aselli G (1627) *De Lactibus sive Lacteis Venis, Quarto Vasorum Mesarai Corum Genere Novo Invento*. Mediolani, Milano
- Bartels P (1909) Das Lymphgefäßsystem. In: von Bardeleben Bd (ed.) *Handbuch der Anatomie des Menschen. Part 4*. Gustav Fischer, Jene
- Cruikshank W (1786) *The Anatomy of the Absorbing Vessels of the Human Body*. G Nicol, London
- Delamere G, Poirier P, Cuneo B (1903) The lymphatics (To the memory of Professor Sappey). In: Poirier P, Charpy A (ed.) *A Treatise of Human Anatomy*. Authorised English edition translated and edited by Leaf CH. Archibald Constable and Co, London
- Gerota D (1896) Zur technik der lymphgefäßinjection. Eine neue injections-masse für lymphgefäße. Polychrom injection. *Anat Anzeiger* 12: 216–24 [in German]
- Haagensen CD, Feind CR, Herter FP et al (1972) *The Lymphatics in Cancer*. WB Saunders, Philadelphia, PA
- Johnson RA, Blake TM (1966) Lymphatics of the heart. *Circulation* 33(1): 137–42
- Kanter MA (1987) The lymphatic system: an historical perspective. *Plast Reconstr Surg* 79(1): 131–9
- Nuck A (1692) *Adenographia Curiosa et Uteri Foeminei Anatome Nova*. Lugduni-Batavorum, Leiden [in Latin]
- Pan WR, Suami H, Taylor GI (2008a) Lymphatic drainage of the superficial tissues of the head and neck: anatomical study and clinical implications. *Plast Reconstr Surg* 121(5): 1614–24
- Pan WR, Suami H, Taylor GI (2008b) Senile changes in human lymph nodes. *Lymphat Res Biol* 6(2): 77–83
- Pan WR, Suami H, Corlett RJ, Ashton MW (2009) Lymphatic drainage of the nasal fossae and nasopharynx: preliminary anatomical and radiological study with clinical implications. *Head Neck* 31(1): 52–7
- Pan WR, le Roux CM, Levy SM, Briggs CA (2010a) Lymphatic drainage of the tongue and the soft palate. *European Journal of Plastic Surgery* 33(5): 251–7
- Pan WR, le Roux CM, Levy SM, Briggs CA (2010b) The morphology of the human lymphatic vessels in the head and neck. *Clin Anat* 23(6): 654–61
- Pan WR, le Roux CM, Levy SM, Briggs CA (2011a) Lymphatic drainage of the external ear. *Head Neck* 33(1): 60–4
- Pan WR, Le Roux CM, Briggs CA (2011b) Variations in the lymphatic drainage pattern of the head and neck: further anatomic studies and clinical implications. *Plast Reconstr Surg* 127(2): 611–20
- Rees MJ, Taylor GI (1986) A simplified lead oxide cadaver injection technique. *Plast Reconstr Surg* 77(1): 141–5
- Rouvière H (1938) *Anatomy of the Human Lymphatic System*. Edwards Brothers, Ann Arbor, MI
- Sappey PC (1874) *Anatomie, Physiologie, Pathologie des vaisseaux lymphatiques*. Adrien Delahaye, Paris [in French]
- Skandalakis JE (1995) I wish I had been there: highlights in the history of lymphatics. *Am Surg* 61(9): 799–808
- Suami H, Taylor GI, Pan WR (2005) A new radiographic cadaver injection technique for investigating the lymphatic system. *Plast Reconstr Surg* 115(7): 2007–13
- Thompson JF, Morton DL, Kroon BBR (2004) *Textbook of Melanoma*. Martin Dunitz, London
- Uren RF, Thompson JF, Howman-Giles RB (1999) *Lymphatic Drainage of the Skin and Breast*. Harwood Academic Publishers, Sydney
- Watanabe H, Komiyama S, Soh N, Kudoh S (1985) Metastases to the Rouviere nodes and headache. *Auris Nasus Larynx* 12(1): 53–6