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Short Report

Lymphatic drainage from the tonsil of the soft palate in pigs

GABRIELLE T. BELZ AND TREVOR J. HEATH

Department of Anatomical Sciences, University of Queensland, Australia

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ABSTRACT

The tonsil of the soft palate, the predominant lymphoid tissue of the oropharynx in pigs, is important especially in initiating immune responses against antigenic material entering the mouth. The aim of this work was to describe the lymphatic pathways from the tonsils of the soft palate of pigs through lymph nodes of the head to the bloodstream. This was achieved by gross dissection, and by using Evans' Blue dye and Microfil casts. Efferent lymphatic vessels from the tonsil coalesce to form vessels which convey lymph to the primary nodes, the mandibular and medial retropharyngeal, and thence to the bloodstream, along two distinct pathways. In the superficial pathway, lymph flows through the mandibular lymph node, along lymphatic vessels closely associated with the linguofacial vein, to the ventral superficial cervical node (middle group) and the accessory mandibular node. Most efferent vessels from the accessory mandibular node enter the ventral superficial cervical node, but some may directly join the lymphatic vessels emanating from the ventral superficial cervical node. These vessels convey lymph to the dorsal superficial cervical node and thence, via the efferent lymphatics, to the circulatory system. In the deep pathway, lymph is conveyed directly to the medial retropharyngeal node and then to the tracheal trunk, as in other domestic animals. As the vessels from the tonsils course over the surface of the pharynx, the muscular movements of swallowing may help propel lymph towards the primary nodes and the bloodstream.

Key words: Pig; lymph nodes; lymphatic vessels; tonsil; lymphoid tissue.

INTRODUCTION

Tonsils play a key role in initiating immune responses against antigenic material entering the oropharynx and in the protection of mucosal surfaces against infection (Brantzaeg, 1984). In pigs, in contrast to other species of domestic animals, the tonsillar tissue is located mainly in the soft palate (Schummer & Nickel, 1979).

Although studies have been made on lymphocyte emigration from the tonsils (Pabst & Nowara, 1984) and on their histopathology (Payne & Derbyshire, 1963; Williams & Rowland, 1972; Narita et al. 1989), little detailed information is available on the pathways taken by lymph as it flows from the tonsils of the soft palate through the complex arrangement of lymph nodes in the head of pigs. The aim of this work was to describe the pathways of lymphatic drainage from the tonsil of the soft palate in the pig. These pathways were studied by gross dissection, and by using Evans' Blue dye and Microfil casts.

MATERIALS AND METHODS

Eight Large White × Landrace pigs, 6–9 wk of age and 14–20 kg in weight, were used. The pigs were killed with an overdose of pentabarbitone sodium (Lethabarb, Virbac (Australia) Pty Ltd, Peakhurst, New South Wales).

Drainage areas from the tonsil of the soft palate were investigated by injecting the soluble protein marker Evans' Blue dye (1 ml of 1% solution; Hopkins & Williams, Chadwell Heath, Essex, England) or the casting material Microfil (1 ml; Flow Tek Inc., Boulder, Colorado, USA) through a 26 G needle placed into the tonsillar parenchyma. Evans' Blue dye is taken up into the lymphatics draining the

Correspondence to Dr Gabrielle Belz, Department of Anatomical Sciences, University of Queensland, Brisbane, Queensland, 4072, Australia.

injection site and carried to the primary and subsequent nodes within a few minutes. However, over time, the dye outlining the lymph vessels becomes progressively paler such that some vessels may not be clearly distinguishable from the surrounding tissues. Therefore, Microfil was used to provide a longer lasting outline of the lymphatic pathways. Evans' Blue or Microfil was introduced into subsequent nodes along the drainage route either through a polyethylene cannula (Dural Plastics and Engineering, Auburn, New South Wales, Australia) placed in an afferent lymphatic vessel, or by intraparenchymal injection at the point where the relevant afferent vessels entered the node. The lymphatic pathways were traced by dissection. These pathways and the distribution of marker were recorded diagrammatically.

Lymph nodes were dissected from the carcass. Nodes containing Evans' Blue dye were labelled to maintain orientation, then fixed (4% paraformaldehyde in 0.067 M sodium cacodylate buffer, pH 7.2) immediately to prevent diffusion of dye to adjacent parts of the node; Microfil casts were allowed to set for 1–2 h prior to fixation. All nodes were dehydrated in a graded series of ethanol, then cleared and examined under methyl salicylate with an Olympus SZ microscope.

RESULTS

Lymph vessels from the tonsil of the soft palate drained along two pathways, (1) superficial and (2) deep, before passing along efferent vessels of the dorsal cervical node or the tracheal trunk to the bloodstream. When Evans' Blue dye or Microfil was injected into the tonsil, the lymphatic pathways and regional distribution of each marker within the nodes was constant (Fig.) and it was assumed that these areas formed the collecting area for the tonsillar lymph.

Superficial pathway

In the superficial pathway, lymphatic vessels draining the tonsil coalesced to form 4 or 5 vessels which coursed within the deep buccal fascia, adjacent to the styloglossus muscle. These vessels emerged at the junction of the styloglossus and digastric muscles and traversed the surface of the digastric muscle before passing to the medial aspect of the mandibular lymph centre. Of the 2–4 nodes forming the mandibular lymph centre, only the most caudoventral node received lymph from this tonsil. From there, the efferent vessels united forming 3 or 4 lymphatic vessels which lay within the fascia dorsal and ventral to the linguofacial vein. Lymph flowing along the ventral vessels entered the accessory mandibular node; those situated dorsally conveyed lymph to the ventral superficial cervical nodes (middle group).

Two or 3 efferent vessels emerged from the accessory mandibular node and either passed over the junction of the linguofacial and maxillary veins to reach the ventral superficial node (middle group), or they directly joined the vessels originating from the ventral superficial cervical node (middle group). Together, these vessels (4–6 in number), passed obliquely across the lateral surface of the brachiocephalic muscle and entered the dorsal superficial cervical node, which was located within a fat pad, partially covered by the omotransversarius muscle. Efferent vessels from the dorsal superficial cervical lymph node coursed medial to the omotransversarius muscle and lateral to the omohyoid muscle to reach the deep cervical lymph nodes. These vessels joined the blood vascular system at the confluence of the internal and external jugular veins, or entered the terminal portion of the tracheal trunk, right lymphatic duct or thoracic duct at the base of the neck.

Deep pathway

In the deep pathway, 2–3 lymphatic vessels emerged from the caudal region of the tonsil and coursed medial to the stylohyoid bone on the abluminal surface of the pharynx and entered the medial surface of the medial retropharyngeal lymph node. From there, the efferent vessels united into 2 or 3 vessels to form the tracheal trunk. The tracheal trunk accompanied the internal jugular vein to the caudal region of the neck where it coalesced with the thoracic duct on the left; on the right, it entered the terminal dilatation of the right lymphatic duct, or entered the venous system directly at the venous angle.

No connections between the deep and superficial pathways were observed.

DISCUSSION

The lymphatic drainage of the tonsils of the soft palate consist of a superficial pathway passing through the mandibular lymph node, and a deep pathway flowing through the medial retropharyngeal lymph nodes. Vessels from both pathways course over the surface of the pharynx and the muscular movements

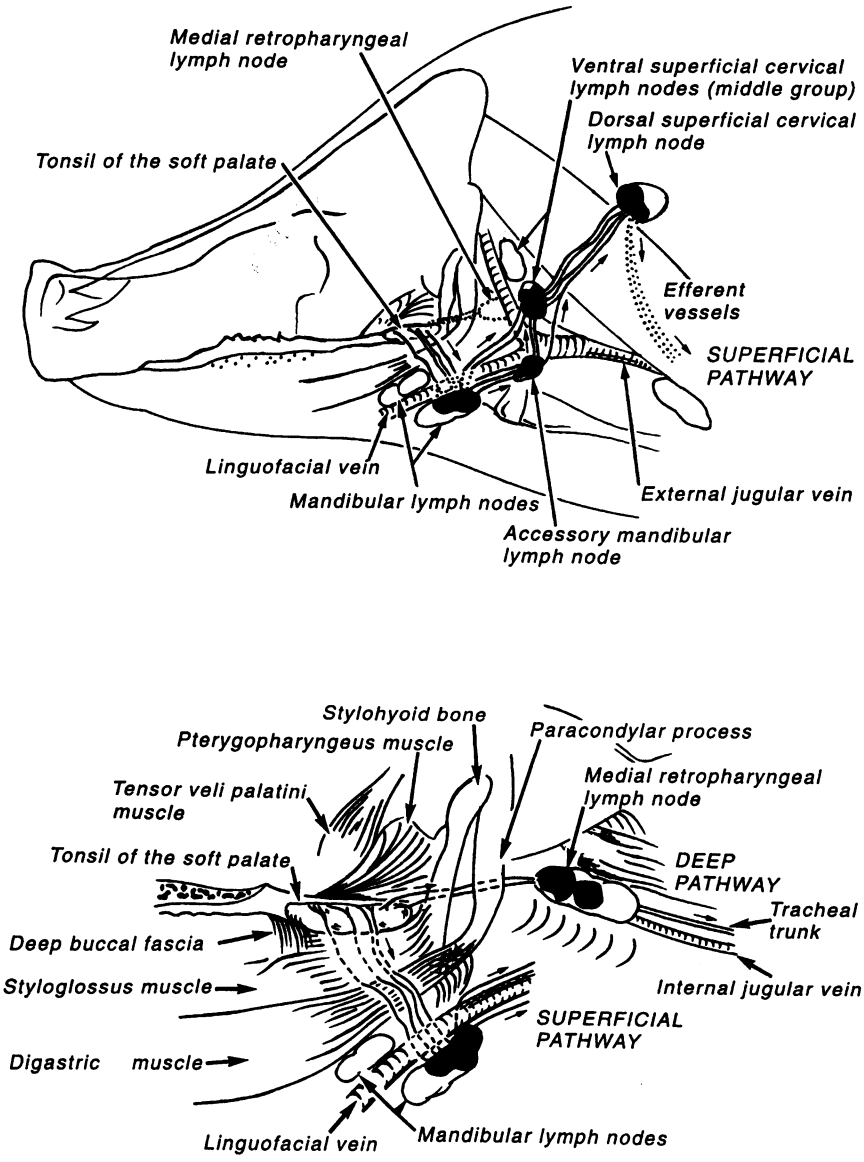

Fig. Diagram of a left lateral view of a pig's head showing lymphatic drainage from the tonsil of the soft palate through the complex of nodes of the head and neck comprising a superficial and a deep pathway. The deep pathway is shown in the lower, slightly magnified diagram. The drainage area to each node is indicated in black (■). Lymphatic vessels which course deep to structures are indicated by a broken line (---). The skin, cutaneous muscles, parotid node and gland, portion of the mandible and maxilla, pterygoid muscles and mandibular salivary gland have been removed.

of swallowing may help propel lymph towards the bloodstream.

That lymph of the tonsil is conveyed to the mandibular lymph centre has been described (Baum & Grau, 1938) and further corroborated by other investigators (Saar & Getty, 1964; Williams, 1972). However, some lymph from the tonsil also flows along a deep pathway to the medial retropharyngeal lymph node, thereby reaching the circulatory system by way of the tracheal trunk, as in other species. Neither Saar & Getty (1964) nor Williams (1972) described this deep pathway in pigs. While it is not clear how much lymph may flow along each pathway, the consistent presence of alternate efferent pathways suggests that each plays a significant role in the drainage of lymph and lymph constituents originating from the tonsil to the primary lymph nodes and bloodstream. Although Anderson (1974) postulated that some lymph from the tonsils flowed to the parotid lymph nodes, this was not supported by our results.

Lymphocyte emigration from the tonsil is significant and occurs at a rate likely to exceed that of the mesenteric nodes (Pabst & Nowara, 1984). In pigs, the efferent lymph contains very few lymphocytes; the lymphocytes in the lymph node directly reenter the bloodstream via the high endothelial venules (Binns &

Hall, 1966). The interfollicular tissue of gut-associated lymphoid tissues is a site, in pigs as in other species, where lymphocytes are continually migrating between blood and lymph. In contrast to lymph nodes, the lymphatic vessels draining some of these mucosal sites (including Peyer's patches) constitute a pathway of heavy lymphocyte traffic (Pabst, 1987; Rothkötter et al. 1993). The vast majority of lymphocytes appear to leave in the efferent lymphatics and migrate into the blood at the high endothelial venules of the primary draining nodes (Bennell & Husband, 1981; Pabst, 1987). However, despite the large number of lymphocytes emigrating from the tonsils (Pabst & Nowara, 1984), the route of emigration remains to be determined.

Pabst & Nowara (1984), who selectively labelled tonsillar lymphocytes with fluorescein isothiocyanate (FITC), observed that the drainage area of the cervical lymph node did not show a higher labelled cell index when compared with adjacent regions of the node. More recently, Binns & Pabst (1988) proposed that the tonsils, in contrast to other gut-associated lymphoid tissues, may exhibit a capacity similar to the lymph nodes for lymphocyte bipolar migration across high endothelial venules. This conclusion has been based on sampling of the cervical lymph nodes alone. In the current study, lymph from the tonsil passed through 2 or more nodes before flowing into the dorsal superficial cervical lymph node. Accordingly, lymphocyte migration from the lymph to blood may occur at a number of sites before reaching the dorsal superficial cervical node.

Although lymph nodes of the pig are structurally inverted compared with other domestic species, their other lymphoid organs such as Peyer's patches (Chu et al. 1979), tonsils (Williams & Rowland, 1972) and spleen (Pabst & Nowara, 1982) are not inverted. Lymphocyte homing to tonsils of the soft palate, like Peyer's patches, is evident from about 70 d gestation and is antigen-independent (Pabst & Binns, 1989). As lymphoid cells of these organs express similar receptor recognition of endothelial determinants (Butcher, 1986), comparable mechanisms may influence lymphocyte extravasation in Peyer's patches and tonsils. The efferent lymphatic pathways of the tonsil are therefore likely to be important for conveying tonsillar lymphocytes to the primary draining nodes—the mandibular and medial retropharyngeal—where many lymphocytes may then migrate into the blood.

Lymph nodes of pigs comprise aggregations of several nodal anlages (Kampmeier, 1969), each of which receives a separate lymph supply (Binns, 1982). The pattern of blood supply, by contrast, exhibits little segmentation; most arteries entering the lymph nodes arise from an anastomosing complex of vessels on the surface of the node (Spalding & Heath, 1986) such that blood constituents are distributed throughout the node.

The soluble protein marker, Evans' Blue, stained consistent regions of nodes, and these may be regarded as the collecting areas for lymph from the tonsil. However, Pabst & Nowara (1984) described a relatively uniform distribution of FITC-labelled tonsillar lymphocytes throughout the superficial cervical lymph node which suggests that most of these cells reached the lymph node via the bloodstream and represent the homing population from the intravascular pool. The lymphatic pathways are therefore likely to play an important role in disseminating soluble factors carried in lymph from the tonsil and to help in the development and propagation of the immune response (Fahy et al. 1980; Fahy, 1980; Mitani et al. 1990).

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