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Observations upon rhinoceros cervical lymphatics

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(With 10 figures in the text)

As an initial contribution to rhinoceros lymphangiology observations are presented upon the disposition of the lymphatic vessels and nodes associated with the larynx, thyroid gland and parathyroid glands of an adult male Indian rhinoceros (*Rhinoceros unicornis*). A detailed account is given of the topography and connexions of the anterior and intermediate groups of cervical lymph nodes and of the lymph drainage of certain cervical organs. The presence is reported, upon inter-nodal afferent pathways, of specialised and hitherto undescribed formations of a lympho-haemal nature and the functional significance of these is suggested.

Contents

Introduction

Information is wanting concerning the rhinoceros lymphatic system since material for lymphatic investigation becomes available but rarely and usually under conditions precluding the employment of the Gerota technique of lymphvascular injection. Further, during the anatomisation of uninjected material the delicate lymph vessels are readily overlooked or suffer destruction in the course of routine dissection. Opportunity was taken, therefore, to investigate the exceptionally well preserved lymphatics of the throat parts of an Indian rhinoceros (*Rhinoceros unicornis*) wherein these structures were sufficiently conspicuous as to permit of their macro-dissection. Such enquiry revealed a plan of cervical lymph node topography together with some details of the lymph drainage of the larynx, hypopharynx, thyroid and parathyroid glands. It also revealed the presence, in

association with certain internodal leashes of afferent lymphatics, of peculiar and hitherto unrecorded formations of a lymphohaemal nature, whose physiological activity invites a fuller investigation.

Material and methods

The laryngo-pharyngeal viscera were excised in continuity during the routine post-mortem examination of a 15 years old male Indian rhinoceros, an animal ("Malik") bred and exhibited (1960–75) in the menagerie of the Zoological Society of London. The parts removed were immediately formalin fixed and were later dissected, microscopical examination being made of the lympho-haemal formations observed upon certain lymphatic pathways. The study material evidenced no pathological change: its oral extremity necessarily suffered some multilation during procuration.

Observations

The cervical fasciae

The deep fascia is thick, tough and collagenous: it condenses locally around blood-vessels (carotid sheath) and viscera (thyroid sheath) and around both individual lymph nodes and node clusters: it supports and provides passage for the lymphatic vessels. The epipharyngeal fascia is a non-fatty, lax areolar feltwork, thickened medianly to bind the

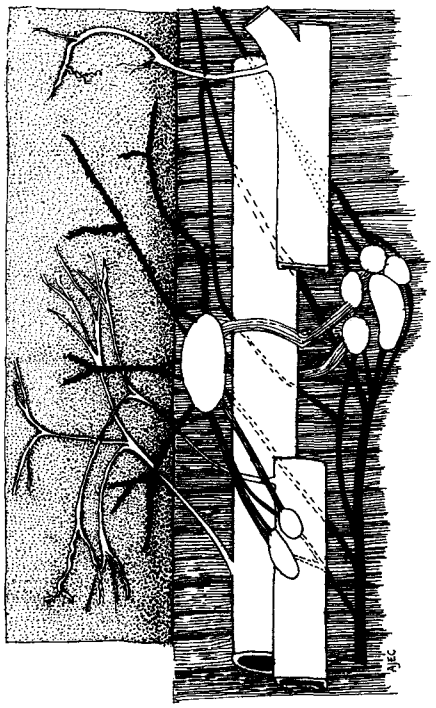

FIG. 1. *Rhinoceros unicornis.* Lymphatic and vascular connexions of the epipharyngeal bura. From a dissection sketch. The bursal wall (stippled) and pharyngeal wall (fasciculated) are depicted with the common carotid artery, the internal jugular vein and the epipharyngeal, epijugular and precarotid nodes (white). Lymphatic afferents (black, beaded), lymphatic efferents (black, solid) and internodal afferent leashes (linear) are indicated.

epiphrayngeal bursa to the pharynx roof: it accommodates the ramifying bursal bloodvessels and lymphatics. The pretracheal fascia comprises a deep, tenuous fibrous stratum and a 6 mm thick superficial fatty stratum, lodging lymphatic vessels some 3 to 4 mm in diameter.

The epipharyngeal bursa

This is a mucosa-lined, thin-walled pyriform fibrous sac (112 mm long × 110 mm maximal width × 20 mm deep) which covers the pharynx roof and overhangs the carotid sheath bilaterally. Its mucosa displays a spiderwork of fine veins and two (anterior, posterior) groups of mammilliform elevations, individually duct-pierced centrally: it is rich in diffuse lymphoid tissue, concentrated around the blood vessels and the ducts of the submucosal glands. Distally the gland ducts are surrounded by lymphoid secondary follicles, responsible for the mucosal mammilliform elevations. The bursa is independently vascularised by an a. epipharyngea, reaching the bursa wall directly from the dorsum of the common carotid and thereon trifurcating into anterior, middle and posterior branches, each of which terminates in a leash of arterial twigs. The definitive bursal veins are three, viz. a vena comes arteriae epipharyngeae (draining directly into the internal jugular vein), a vena anterior (which joins a jugular pharyngeal tributary) and a large vena mediana (which disappears through the pharyngeal raphé). The bursa lymphatics are detailed below (Fig. 1).

The lympho-haemal formations

Certain curious and hitherto undescribed formations, of a specialised lympho-haemal nature, are prominent upon some afferent lymphatic pathways, notably upon those in direct or proximate relationship to the largest (carotid) bloodvessels. Macroscopically each such formation is an almond-shaped "patch" of extremely soft consistency and reddish (or brownish) colour, in continuity with lymph vessels at each of its ends. Such "patches" are most obtrusive upon those leashes of internodal lymphatic vessels which pass under or over the common carotid artery, adherent to, or even embedded in, its adventitial coat. They are absent from the efferent lymph vessels (Fig. 2). Microscopically each "patch" resembles an intensely vascularised arrangement of diffuse lymphoid tissue. It comprises a loose connective tissue framework, traversed longitudinally by lymphatic channels, arterioles and venules, and manifesting a scattered complement of lymphocytes, erythrocytes and polymorphonuclear leucocytes. Within the highly vascular and loosely organised lymphoid tissue of the formation occur numerous fine vessels, disposed in a parallel series and constituting tributaries of the major lymphatic channels associated with the "patch". These fine vessels much resemble veins in their structure and disposition and are brownish-red in colour from their content of haemal elements: these contents pass into the lymphatic vessels draining the formation. The source of the arterial supply of the formation remains undetermined but is probably provided by fine innominate vessels from the common carotid artery. The formation apparently represents a mechanism providing a permanent connexion between the lymphatic and the bloodvascular systems, whose full functional significance requires elucidation by appropriate physiological investigation. The morphological evidence suggests that such a specialised modification of the lymphatic pathway is designed to subserve the interim return of lymph into the bloodstream, the interchange of lymphoid and haemal elements and the re-circulation of lymphocytes (Fig. 3).

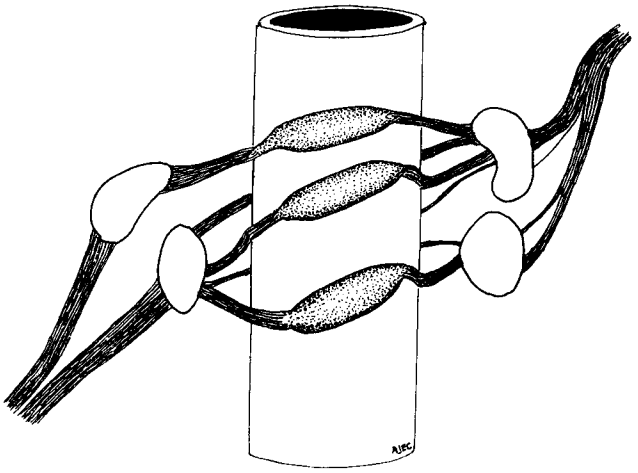

FIG. 2. *Rhinoceros unicornis.* Common carotid artery and internodal leashes of lymphatic afferents. On each ventral leash a specialised lympho-haemal formation is developed.

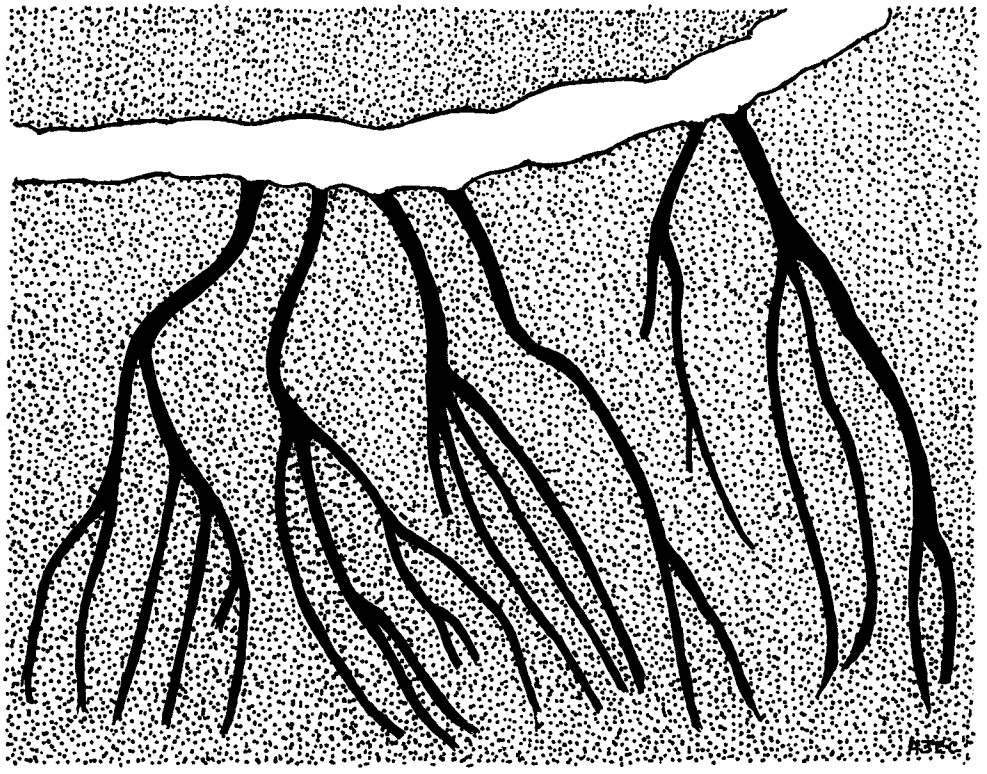

FIG. 3. *Rhinoceros unicornis.* Lymphatic vessel traversing a lymphohaemal formation and receiving vein-like tributaries (black) from the diffuse lymphoid tissue (stippled) of the formation. Diagrammatic.

The cervical lymph nodes

The topography of the cervical lymph nodes in the present rhinoceros specimen confirms that observed more cursorily in specimens previously examined. Basically these nodes form (a) an anterior group around the terminal common carotid artery, (b) an intermediate group scattered obliquely alongside the trachea, (c) a posterior group adjacent to the thoracic inlet, a grouping similar to that obtaining in the horse. The anterior cervical node group is separable topographically into pre-carotid, epipharyngeal and epijugular components (Fig. 4). The pre-carotid component is a cluster of six nodes ventrad of the terminal common carotid and individually and collectively so fascia-enwrapped as to form a solid oval mass (80×50 mm) split into deep and superficial moieties by traversing bloodvessels. These vessels include a relatively large nodal artery from the common carotid, a second nodal artery from the internal carotid, a large itinerant pharyngeal vein and two large veins draining the cluster itself (Fig. 5). The cluster comprises two large, reniform, nodes (23×14 mm, 20×15 mm respectively) and four smaller, ovoid nodes (17×10 mm, 15×11 mm, 15×7 mm, 12×10 mm respectively).

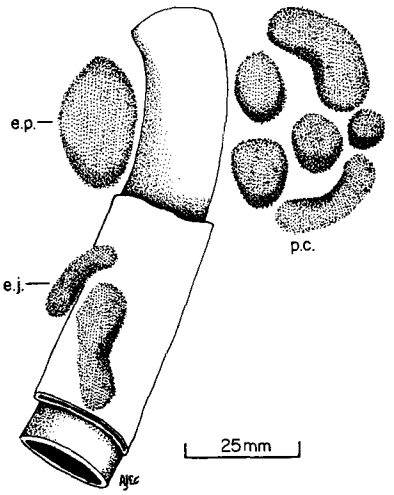

FIG. 4. *Rhinoceros unicornis.* The topography and relative dimensions of the anterior cervical group of nodes. Drawn to accompanying 25 mm scale. e.j.=epijugular nodes: e.p.=epipharyngeal node: p.c.=precarotid nodes.

The epipharyngeal component is an outlying single, large (30×17×5 mm) node upon the pharynx wall, dorsad of the terminal common carotid and ventrad of the lateral parietes of the epipharyngeal bursa.

The epijugular component comprises two outlying reniform nodes (30×9 mm, 15×5 mm respectively) upon the jugular vein, somewhat caudad of the pre-carotid component.

All the nodes of this anterior cervical group are mutually connected by internodal leashes of lymphatic afferents (Fig. 6).

The intermediate cervical node group is a discontinuous chain of smallish (7×5 mm) flattened ovoid nodes, of fairly uniform shape and size, which extends obliquely alongside the trachea in cranio-caudal direction. Some five or six of these nodes form a loose aggregation at the cranial end of the chain, close to the thyroid caudal pole and the recurrent laryngeal nerve (Fig. 9).

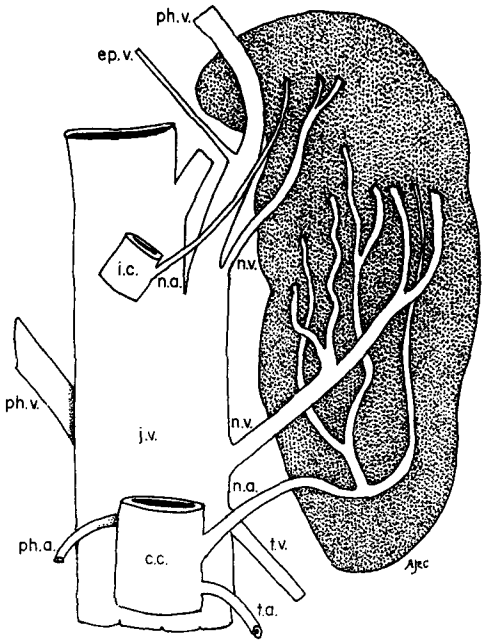

FIG. 5. *Rhinoceros unicornis*. Ventral aspect of dorsal moiety of anterior cervical node mass and associated bloodvessels. c.c. = common carotid artery: ep.v. = epipharyngeal vein: i.c. = internal carotid artery: j.v. = internal jugular vein: n.a. = nodal artery: n.v. = nodal vein: ph.a. = pharyngeal artery: ph.v. = pharyngeal vein: t.a. = superior thyroid artery: t.v. = superior thyroid vein.

The posterior cervical node group is wanting from the present material, but its presence *in vivo* is attested to by the number, size and alignment of the efferent lymphatics proceeding caudally from the anterior and intermediate node groups.

Prelaryngeal and pretracheal nodes are nowhere detectable.

The cervical lymphatic vessels

In general

An expected pattern of structure and disposition is manifested by the lymphatic vessels of the present specimen. Afferents arise from the subepithelial plexuses underlying cutaneous, mucous, synovial or serous surfaces designed to preserve the essential suppleness of those surfaces. They frequently by-pass the nearest lymph node on their course, to enter one more distant and may divide before entry. They may terminate directly in the larger local veins, a phenomenon sometimes doubted or denied, but strikingly apparent in the present material (Fig. 7). Without such peripheral and continuous seepage of lymph into the venous system the terminal lymphatic and venous channels (thoracic duct, venae cavae) would be of equal calibre, which is patently not so.

The nodes constituting the anterior cervical group are interconnected by leashes of lymphatic vessels, simultaneously efferent from one node yet afferent to another: such connectants are therefore termed internodal leashes (Fig. 6). Such leashes are intimately related to the common carotid artery, often adherent to, or embedded within, its tunica

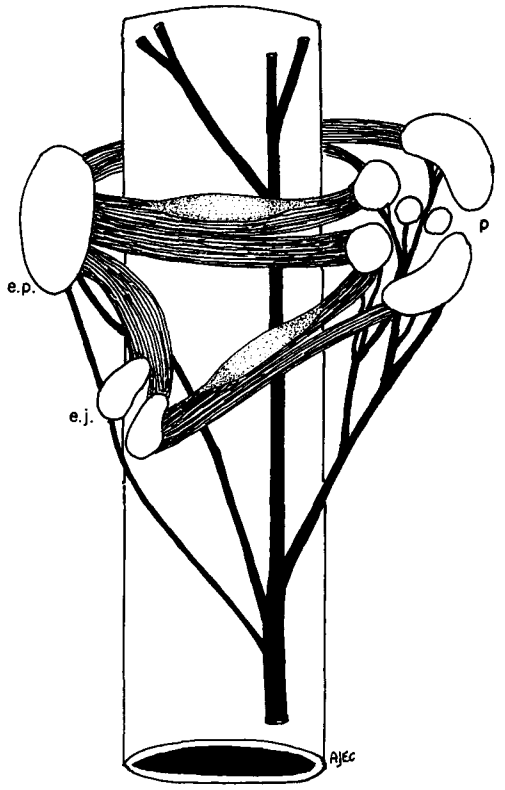

FIG. 6. *Rhinoceros unicornis.* Anterior cervical lymph node group and associated lymphatics in relation to the common carotid artery. Diagrammatic. Afferent vessels in linear series: efferent vessels black: lympho-haemal formations stippled: e.j.=epijugular nodes: e.p.=epipharyngeal node: p.=precarotid nodes.

adventitia. Upon these leashes occur the peculiar lympho-haemal formations already noted: they are absent from the thicker-walled major efferent lymphatics. These last proceed caudally, uniting in irregular fashion to form larger vessels which terminate either in the cervical lymph trunk or in the posterior cervical nodes.

Apart from the internodal leashes, large-calibred lymphatic afferents are readily observable in the laryngeal aditus, upon the pharyngeal wall, over the thyroid gland and as a localised meshwork of vessels (infrathyroid plexus) immediately below the cricoid cartilage.

Of the epipharyngeal bursa

Four macroscopically recognisable afferents (some 1 mm in diameter) arise from the bursa and pass to the epipharyngeal (postcarotid) node, three taking a short course thereto, the fourth a longer course from its temporary accompaniment of a large palato-faucial afferent descending to the epijugular nodes. All the bursa lymph thus reaches the epipharyngeal node and this node receives no afferents from any other source: it is therefore the exclusive receptacle for the bursa lymph. It gives rise to internodal afferents and descending efferents: the former travel in leash fashion, under, over or between the great

blood vessels, ventrally to the dorsal two nodes of the precarotid cluster and more caudally to the major epijugular node. Upon these internodal leashes the lymph–haemal formations are prominently developed. A shorter efferent vessel descends to the minor epijugular node, a longer efferent joins the efferents of the precarotid nodes (Figs 1–6).

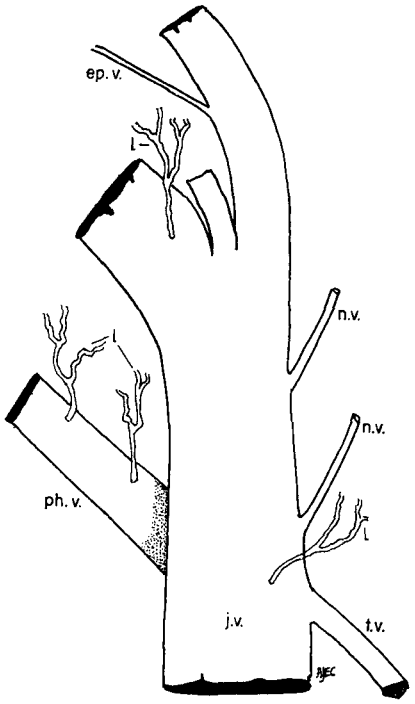

FIG. 7. *Rhinoceros unicornis.* Lymphatic vessels entering veins. ep.v. = epipharyngeal vein: j.v. = internal jugular vein: l. = lymphatic afferent: n.v. = nodal vein: ph.v. = pharyngeal vein: t.v. = superior thyroid vein.

Of the sinus pyriformis

The sinus pyriformis is that ventral region of the pharynx lying between the laryngeal and pharyngeal walls: its lymph drainage is therefore part of the general pharyngeal drainage but for topographical convenience is best considered separately. The outflow of lymph from this sinus is surprisingly large and altogether in excess of what might reasonably be anticipated in view of the limited area of mucosa lining the sinus walls. This apparent discrepancy is accounted for, however, by the presence within the sinus of an unsuspected but considerable mass of organised lymphoid (tonsillar) tissue (tonsilla laryngo-pharyngea, tonsilla navicularis). Whether this mass of tonsillar tissue be a mere caudal extension of the faucial tonsil or an independent morphological formation is presently irrelevant and will be the subject of consideration elsewhere. The presence of the mass explains the relatively large outflow of lymph from the sinus, the correspondingly large calibre of the sinus afferents and, possibly, the provision of a thyroid foramen in the ala of the thyroid cartilage. In the horse no such thyroid foramen is developed in the thyroid cartilage ala and no tonsillar formation is developed within the sinus.

The ultimate lymph drainage of the sinus is into the precarotid and epijugular nodes of the anterior cervical node group. This is effected by a substantial (3·5 mm diameter) superficial pharyngeal afferent which is formed towards the lower border of the cricoid cartilage by three principal tributaries. These tributaries are:

(i) a large calibred, well-beaded sinus afferent (2·5 mm in diameter) which leaves the sinus through the thyroid foramen, becomes superficial between the middle and inferior contrictor muscles and makes a curvilinear descent across the inferior constrictor towards the caudal border of that muscle. Thereabouts it is joined by

(ii) an afferent of slightly smaller calibre, which pierces the cricothyroid membrane to become superficial between the inferior constrictor and the infrahyoid musculature to pass caudally parallel to the first afferent: this second afferent receives directly

(iii) a smaller afferent which becomes superficial by piercing the cricohyoid membrane and the overlying inferior constrictor muscle (Fig. 8).

The superficial pharyngeal afferent forms an anteriorly concave loop after its formation receives an indirect cricotracheal tributary and a succession of direct tributaries from the

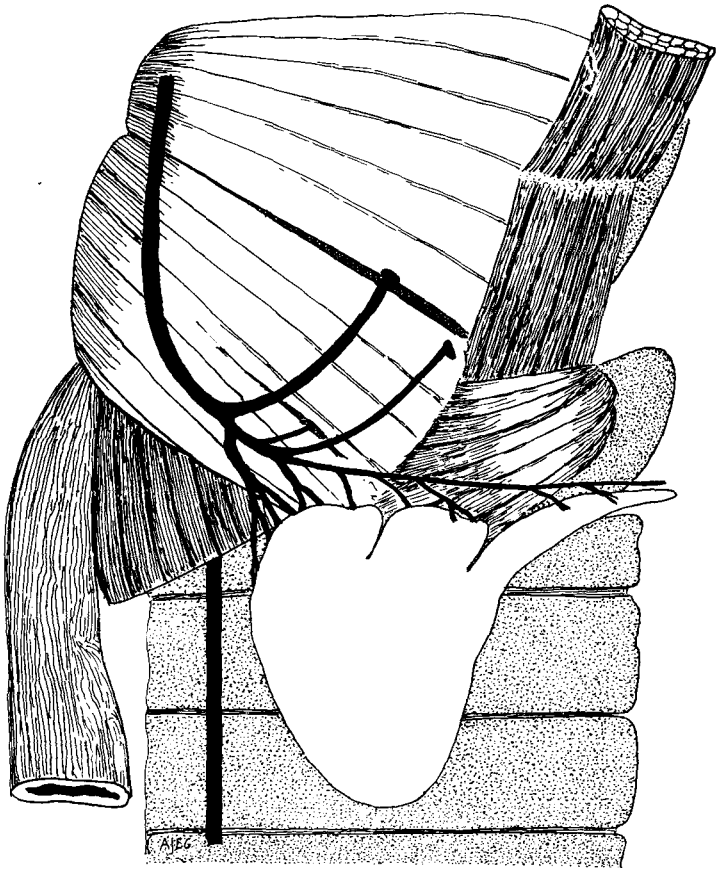

FIG. 8. *Rhinoceros unicornis*. Thyroid cranial afferent lymphatics joining afferents from sinus pyriformis and hypopharynx. (Lymph vessels and recurrent laryngeal nerve black).

cranial moiety of the thyroid gland. Now some 3 mm or more in diameter it ascends the pharyngeal wall dorso-cranially towards the anterior cervical nodes. Before attaining those nodes the vessel divides into a shorter cranial and a longer caudal branch: the first of these trifurcates to connect with the ventral three nodes of the precarotid cluster, the second subdivides to connect with the epijugular nodes.

Of the larynx

Lymph flow from the largely musculo-cartilaginous larynx is expectedly minimal since it derives almost exclusively from the mucosa lining the organ's interior. The mucosa clothing the dorsal and lateral aspects of the larynx is canonically pharyngeal and its lymph drainage therefore part of the pharyngeal lymph drainage. Lymph vessels from larynx and pharynx have a common node reception both cranially (anterior cervical nodes) and

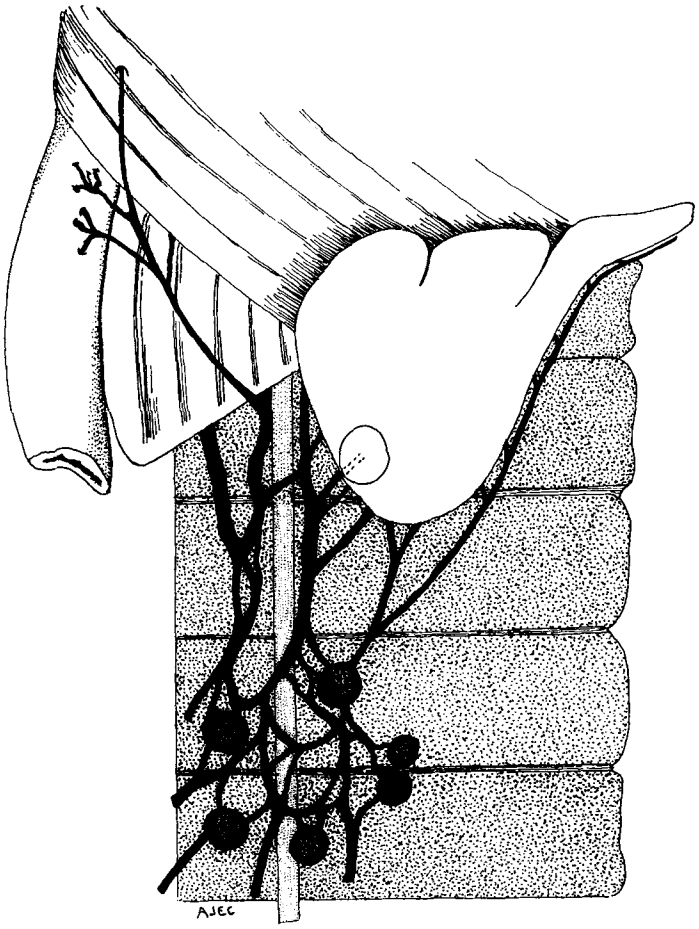

FIG. 9. *Rhinoceros unicornis*. Dextral infrathyroid lymphatic plexus and associated paratracheal nodes. Afferent lymphatics from the caudal thyroid moiety, the laryngeal infraglottic compartment and the pharyngo-oesophageal region are shown entering the plexus.

caudally (intermediate cervical nodes) and may communicate to a trifling degree through the non-muscular area of the laryngeal wall.

Mutilation of the specimen precludes a complete mapping of the course of afferent lymph vessels draining the laryngeal aditus and supraglottic compartment, whilst the vessels of the vocal cords, vestibule and saccule are too fine for dissection. Nevertheless the anatomical evidence available clearly indicates the presence of a lymphatic watershed at the glottic level, lymph from the supraglottic compartment of the larynx draining into the anterior cervical nodes, lymph from the infraglottic compartment draining into the intermediate (paratracheal) nodes (Fig. 9).

Afferents detectable in the laryngeal aditus and supraglottic compartment include:

(i) two large-calibred, roughly parallel vessels running dorsoventrally within the aryepiglottic fold;

(ii) a smaller vessel from the larynx dorsum, entering the fold and joining the foregoing;

(iii) a vessel ascending the supraglottic compartment in the angle between its wall and the epiglottic cartilage to enter the aryepiglottic fold;

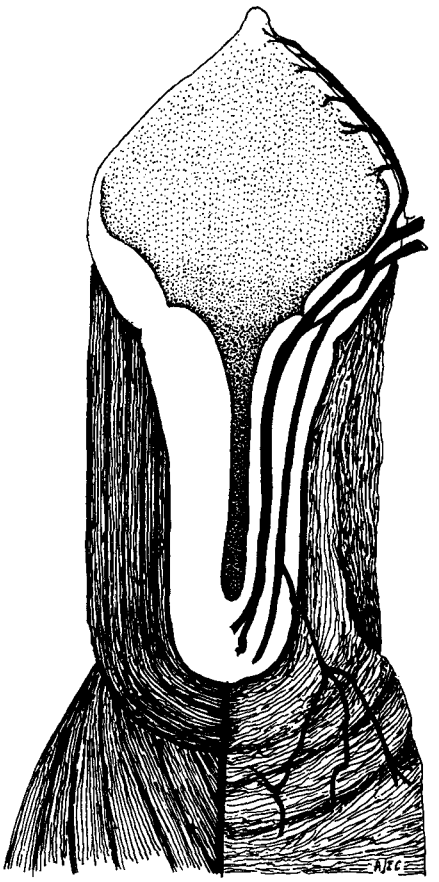

FIG. 10. *Rhinoceros unicornis.* Laryngeal aditus and lymphatic afferents in relation to aryepiglottic fold. Mucosa over cricoid lamina *in situ* dextrally, removed sinistrally, to expose m. palatopharyngeus and m. cricoarythenoideus posterior. Diagrammatic.

(iv) vessels of small size running caudo-laterally towards the aryepiglottic fold along the dorsal and ventral aspects of the free part of the epiglottis (Fig. 10).

Within the ventral extremity of the aryepiglottic fold these several afferents tend to unite into two large and parallel vessels which pass cranialwards deep to the thyrohyoid membrane and the hyoid bone. At or about the cranial margin of the middle constrictor muscle they enter a tangle of larger afferents from the palate, fauces and tongue region and either as tributaries of these, or independently, drain their lymph into the precarotid cluster of anterior cervical nodes. (No afferents pierce the very short and thick thyrohyoid membrane.)

The infraglottic compartment is drained by two terminal afferents. These are large vessels (4·0 mm or more in diameter) which emerge superficially from under cover of the cricoid ring, accompany the recurrent laryngeal nerve among the tributaries of the inferior thyroid vein and enter into the formation of the wide-meshed infrathyroid lymphatic plexus. Thence their lymph passes to the cranialmost paratracheal nodes, to be conveyed ultimately into the posterior cervical lymph nodes.

Of the thyroid and parathyroid glands

The afferent lymphatics of the thyroid gland emerge both from the surface of the organ and directly from the lobe parenchyma. The arrangement of the dissectable surface afferents is strongly suggestive of the presence of a superficial lymphatic plexus which escapes demonstration by gross dissection. Lymph is drained from the gland by two anatomically distinct sets of afferent vessels, viz. a cranial (superior) set passing to the precarotid and epijugular nodes of the anterior cervical group and a caudal (inferior) set passing to the intermediate cervical (paratracheal) nodes. The cranial afferents drain the cranial moiety of the gland, the caudal afferents its caudal moiety, and despite the presence of any superficial thyroid plexus the gland drainage manifests a distinct watershed arrangement.

The thyroid cranial afferents leave the cranial borders of the isthmus and lateral lobe as a series of vessels of diminishing length but increasing calibre (Fig. 8). These cross the lowest portions of the posterior cricoarytenoid and inferior constrictor muscles, join the large superficial pharyngeal lymphatic afferents from the sinus pyriformis and thereby conduct their lymph into the precarotid and epijugular nodes (Fig. 8).

The thyroid caudal afferents average some 2·0 mm in diameter: they descend from the caudal aspect of the isthmus and lateral lobe or emerge directly from the substance of the thyroid caudal pole. Below this pole they form a small, localised wide-meshed macroscopic network (infrathyroid plexus) which is reinforced by afferents from the laryngeal infraglottic compartment, the hypopharynx and the initial oesophagus. The plexus covers the third, fourth and fifth tracheal rings and is intimately associated with a loose cluster of some half-dozen paratracheal nodes: lymphatics leaving the plexus measure 3·0 to 4·0 mm in diameter and proceed caudally as afferents to, or annectants with, the posterior cervical nodes.

The parathyroid gland gives rise to a single, well-beaded and relatively large afferent, which emerges from its deep aspect and descends almost vertically to join a large afferent from the thyroid caudal pole: the conjoint vessel enters the infrathyroid plexus and so conveys its lymph into the cranialmost paratracheal nodes (Fig. 9).

Of the pharynx

The details of oropharyngeal lymph drainage are not determinable, though it is abundantly clear that this region drains into the precarotid and epijugular nodes in company with other large-calibred afferents from the lingual, palatal and faucial regions. The sinus pyriformis lymph drainage is detailed above. Drainage of the hypopharynx and pharyngo-oesophageal junction is effected by a long, superficial and fairly capacious vessel which courses dorsoventrally along the caudal margin of the pharyngeal inferior constrictor. This prominent afferent is formed by (i) small oesophageal tributaries which pierce the wall of that tube, (ii) a tributary which pierces the inferior constrictor muscle and (iii) a tributary descending from under cover of that muscle's caudal edge. The afferent follows the constrictor caudal border, crosses the posterior cricoarytenoid muscle and the recurrent laryngeal nerve and enters the infrathyroid plexus, to discharge its lymph into the cranialmost paratracheal nodes (Fig. 9).

Summary of lymph drainage

In the present specimen the following pattern of lymph drainage is observable:

(i) from the epipharyngeal bursa into the epipharyngeal (postcarotid) node;

(ii) from the oropharynx into the precarotid nodes and from the hypopharynx into the cranialmost paratracheal nodes;

(iii) from the lingual, palatal and faucial regions into the precarotid and epijugular nodes;

(iv) from the sinus pyriformis into the precarotid and epijugular nodes;

(v) from the larynx aditus and supraglottic compartment into the precarotid nodes, from the infraglottic compartment into the paratracheal nodes;

(vi) from the cranial moiety of the thyroid gland into the precarotid and epijugular nodes, from the caudal moiety into the cranialmost paratracheal nodes;

(vii) from the parathyroid gland into the cranialmost paratracheal nodes.

A watershed is discernible in relation to the lymph drainage of the larynx and of the thyroid gland and appears to be probable with respect to the lymph drainage of the pharynx.

Commentary

This investigation remained limited in scope because of the impracticability of employing the Gerota injection technique and consequently various details of lymphatic drainage are left undetermined. Nevertheless the investigation established the precise topography of the anterior and intermediate cervical groups of lymph nodes, the functional independence of the epipharyngeal node, the lymph drainage pattern of the larynx, sinus pyriformis, thyroid and parathyroid glands, and the hitherto unrecorded presence of specialised lympho-haemal formations upon certain afferent lymphatic pathways. It also demonstrated unmistakably the entrance of peripheral lymph vessels directly into the local veins.

The exclusive drainage of the epipharyngeal bursa by a single and topographically distinct node harmonises with the rôle of that bursa as the effective tonsil of the epipharynx. A lymphatic watershed is apparent in the lymph vasculature of the larynx and of the thyroid gland.

The specialised lympho-haemal formations observed upon certain afferent lymphatic

pathways merit more detailed investigation by physiological techniques. It is not known whether similar formations occur in regions other than the cervical. Their morphology suggests that such formations subserve the interchange of lymphoid and haemal elements.

The cervical lymph node topography of the present Indian rhinoceros specimen closely resembles that obtaining in the horse and is suggestive of a common perissodactyl pattern of cervical lymphvascular topography. Whether any such common pattern does obtain is presently undeterminable and must remain so until standard veterinarian treatises shall accord the equid cervical lymph vessels a more detailed attention than is their custom to allow.

Gratitude is hereby tendered to the Council of the Zoological Society of London for the gift of the specimen presently studied, to the Society's Senior Veterinary Officer (Mr D. M. Jones) for his co-operation in procuring the specimen, and to the Society's former Pathologist (Dr Ian Keymer) for the kind provision of histological preparations.