Lymphology 39 (2006) 26-32

RENAL LYMPHATIC DRAINAGE AND THORACIC DUCT CONNECTIONS: IMPLICATIONS FOR CANCER SPREAD

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ABSTRACT

Studies on renal lymph drainage have generally described lymph nodes without further investigation of the lymph vessels. Our purpose was to revisit this organ to study the vessel drainage pattern. This investigation was performed on 16 refrigerated adult cadavers. After both kidneys were injected with a blue modified Gerota mass, lymph vessels were dissected until their termination. From the right kidneys (n=13), lymphatics (n=8) traveling on the anterior aspect of the inferior vena cava were dissected, reaching interaortocaval and more distant nodes, aorta bifurcation (n=1) and left lateroaortic (n=1); posterior lymphatics were observed in all subjects, uniformly connecting to the thoracic duct, either after crossing nodes (n=8) or directly (n=5). From the left kidneys(n=13), anterior efferents (n=16) were dissected, reaching left lateroaortic and also celiac (n=4) and iliac (n=1) nodes; posterior lymphatics were also demonstrated, always connecting to the thoracic duct (3 directly). Renal lymphatics have been found to reach very distant nodes as well as always connecting to the origin of the thoracic duct. This feature suggests an important role in both the formation of the thoracic duct and in the spread of renal cancer.

Keywords: kidneys, lymphatics, thoracic duct, renal cancer, hematogenous/ lymphogenous metastasis, chyluria

The renal lymphatic drainage has been widely studied (1-4). All investigators describe anterior efferent lymphatics of the right kidney traveling on the anterior aspect of the inferior vena cava transversely to interaortocaval lymph nodes (LNs) extending from the left renal vein to the height of the bifurcation of the aorta, and posterior lymphatics following as a rule the renal artery and emptying into retrocaval paraaortic LNs located in front of the right crura. All reports also describe anterior efferents of the left kidney advancing toward left lateroaortic LNs generally in an oblique downward direction, and posterior efferent lymphatics following the course of the renal artery and draining into paraortic LNs located in front of the left crura. Besides these classical lymph vessel patterns, Cunéo (1) and Parker (3) also reported injection of preaortic LN, and Delmas et al (4) once observed a right paraaortic LN visualized by a left kidney injection. Furthermore, Cunéo (1) mentioned, without further description, that efferent lymphatics of the paraaortic LN located in front of the diaphragmatic crura connected to the thoracic duct (TD) after crossing behind the diaphragmatic crura along the sympathetic nerve, which Delmas et al (4) also observed once after a left kidney injection. The purpose of this study was to revisit the renal lymph drainage and to further document its intrathoracic lymphatic vessel pathways.

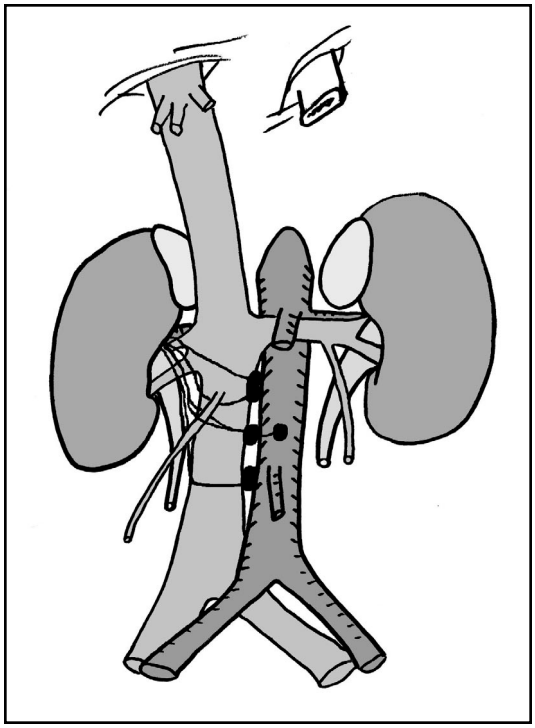

Fig. 1. Right kidney: anterior efferent lymphatics connecting to interaortocaval LNs (4 subjects).

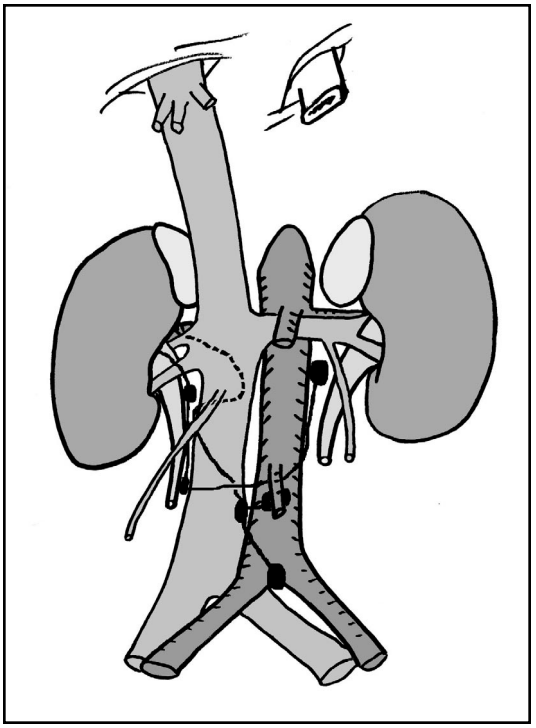

Fig. 2. Right kidney: anterior lymphatics connecting to aortic bifurcation and left lateroaortic LN (2 subjects).

MATERIAL AND METHODS

The study was performed on 16 cadavers (15 females and 1 male) age from 44 to 99 years (mean 85.9). The procedure was carried out at intervals varying from 5 to 15 days after death (mean 9.5 days). All cadavers were free from chest and intraabdominal disease and had been refrigerated; none had been embalmed. The cadaver was placed in dorsal decubitus and after sternolaparotomy, the heart, liver, stomach, spleen, and intestine were removed from the first jejunal loop to the sigmoid. The cadaver was then rewarmed with water at 50°C. A blue colorant (modified Gerota mass) was injected into the parenchyma of the anterior aspect of each kidney using pedal lymphography techniques. Injection was performed using a syringe and minimal manual pressure, and a 1 to 2 ml aliquot of dye was injected each time. Two injections were performed on each side at the upper and lower part of the kidney. The lymphatic efferents from the kidneys were dissected along their course within the retroperitoneum and within the mediastinum to their termination. The dissection was facilitated by using magnifying lenses. At each stage, the dissection was photographed from several angles, and an illustrated report was written for each subject. Of the 32 kidneys injected, 26 injections were successful (13 on the right and 13 on the left).

RESULTS

Right Kidney (n = 13)

Anterior efferent lymphatics traveling on the anterior aspect of the inferior vena cava were observed six times (8 lymphatic vessels). They connected to interaortocaval LN

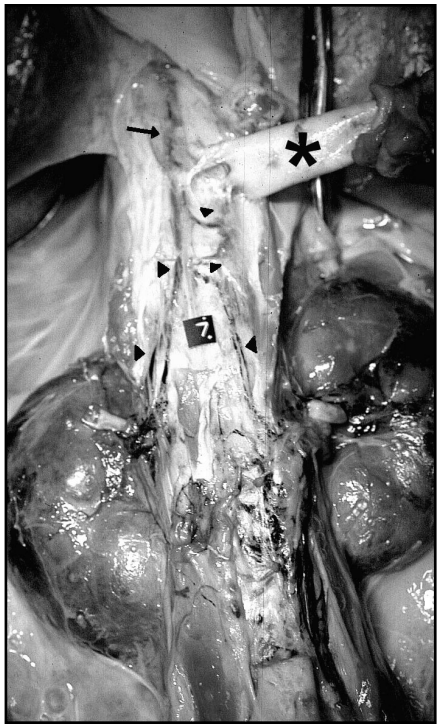

*Fig.3. Bilateral injections demonstrating nodeless lymphatics (arrow heads) ascending along the posterior aspect of the aorta and contributing to thoracic duct formation (arrow); * = severed aorta.*

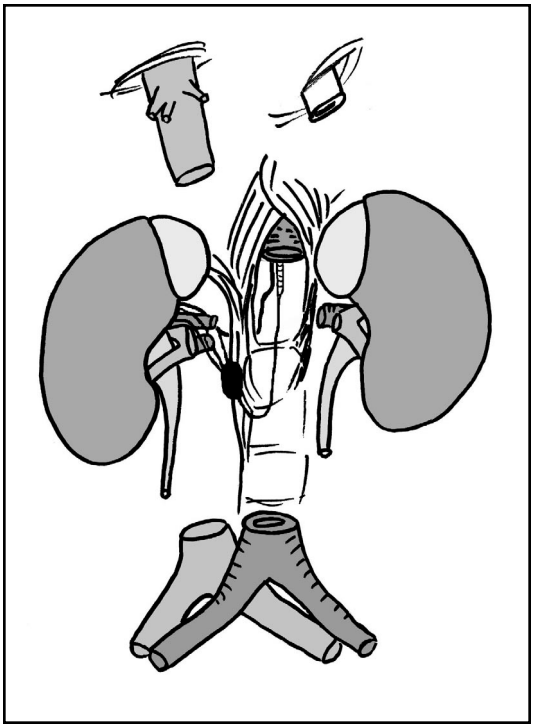

Fig. 4. Right kidney: posterior efferent lymphatics connecting to the thoracic duct after passing through a retrocaval paraortic LN (8 subjects).

extending from the left renal vein to the height of the bifurcation of the aorta four times (6 lymphatics) (*Fig. 1*): efferent lymphatics from these LNs reached the origin of the thoracic duct (TD) once (from an upper LN) and twice from a preaortic LN. In 2 other preparations (*Fig. 2*), the lymphatics traveling on the anterior aspect of the inferior vena cava were found to follow from the posterior aspect of the vena cava and from the right in front of it to a lower interaortocaval LN and then divide toward a LN at the origin of the inferior mesenteric artery and subsequently to another LN located at the aortic bifurcation. In the second subject, a lymphatic reaching two right paracaval LNs and crossing further over the vena cava and the aorta ran upwards to a left latero-aortic LN located at the level of the left renal artery and then to the TD origin.

Median and posterior efferent lymphatics following the right renal artery were present in all subjects and consisted of 18 lymphatic vessels which connected to the TD and contributed to its origin (*Fig. 3*). Lymphatics connected to retrocaval paraaortic LNs located in front of the right diaphragmatic crura eight times, to a LN located above the right renal artery twice, and to LNs at the level of the celiac and superior mesenteric artery once. From the eight paraaortic LNs, efferent lymphatics connected to the TD origin running upwards on the posterior aspect of the aorta, and one drained posteriorly to the right diaphragmatic crura (*Fig. 4*)). Lymphatics (n = 7) connected to the TD directly without encountering any LN five times, followed the posterior aspect of the aorta twice, traversed behind the right diaphragmatic crura once, and divided before following both the pathways twice (*Fig. 5*).

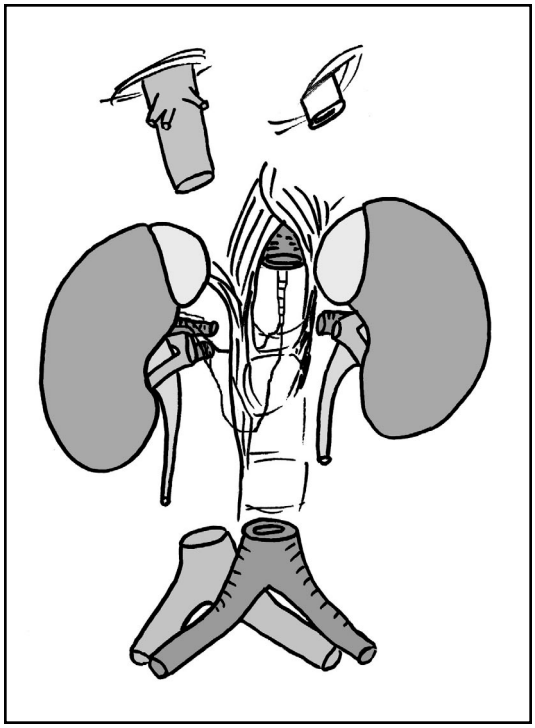

Fig. 5. Right kidney: posterior lymphatics with direct (nodeless) connection to the thoracic duct (5 subjects).

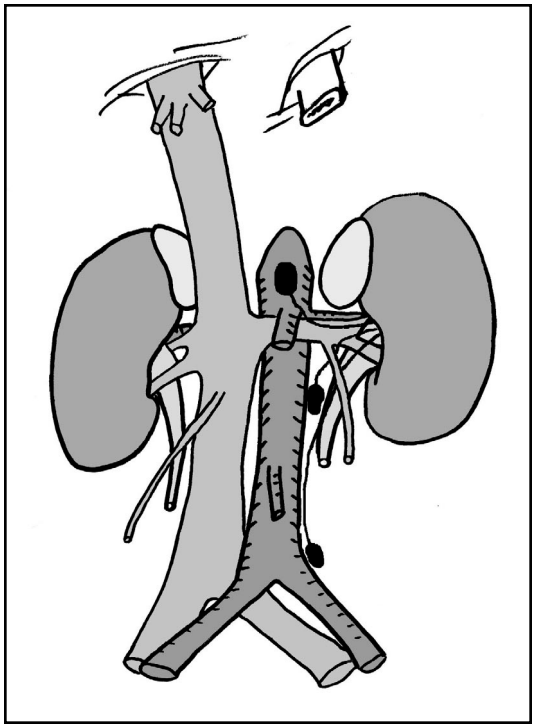

Fig. 6. Left kidney: anterior efferent lymphatics connecting to lateroaortic and celiac LNs (9 subjects).

Left Kidney (n = 13)

Anterior efferent vessels of the left kidney were observed in nine subjects consisting of 16 lymphatic vessels (*Fig. 6*). Efferents advancing toward the left lateroaortic LNs were observed nine times. Lymphatics draining to LNs located at the level of the coeliac artery and at the level of the superior mesenteric artery were observed four times. Efferents running in an oblique downward direction were observed three times reaching an aortic LN located at the level of the primary iliac artery in one subject.

Posterior efferent lymphatics followed the course of the left renal artery and connected with the TD nine times. In five subjects, these posterior efferents were present with anterior efferents, whereas in the remaining four subjects, no anterior vessels were seen. The posterior efferents consisted of 12 lymphatic vessels, eight of which reached LNs located in front of the left diaphragmatic crura before traveling further. Three vessels traversed behind the left crura, and the other nine vessels connected to the TD after traveling upwards along the posterior aspect of the aorta (*Fig. 7*). The TD was generally right-sided, but there was an associated left TD in two subjects. In these subjects, the TD was filled through nodeless lymphatics which had traversed behind the diaphragmatic crura (*Fig. 7*).

Finally, the TD was further dissected within the inferior posterior mediastinum whenever possible, and in one instance, we observed a lymphatic vessel originating from the right lung and connecting with the TD at the level of the tracheal bifurcation (*Fig. 8*).

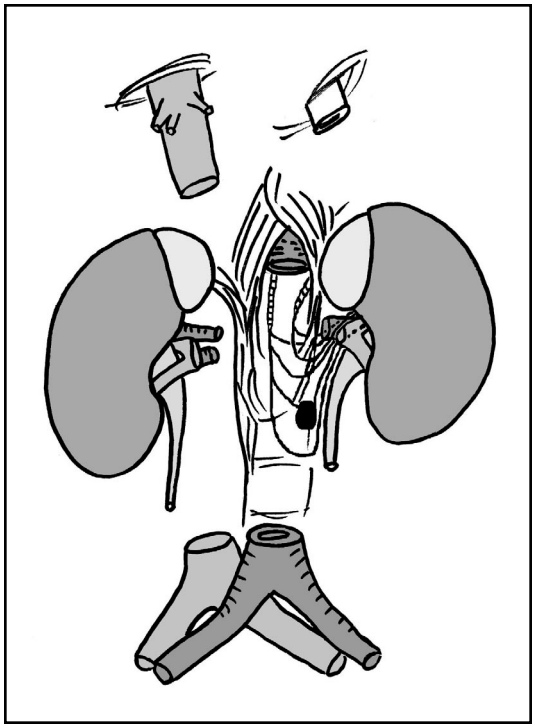

Fig. 7. Left kidney; posterior efferent lymphatics connecting to the thoracic duct (9 subjects). Lymph nodes were seen in 8 subjects. An associated left TD was present in 2 subjects.

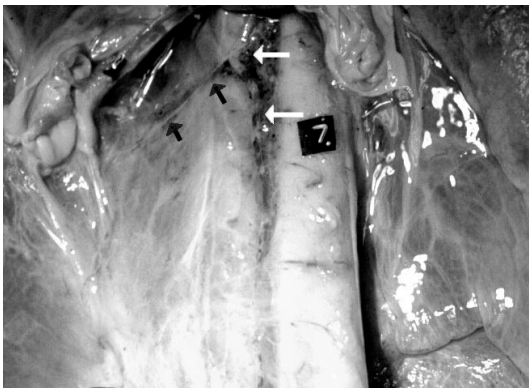

Fig. 8. Lymphatic vessel (black arrows) connecting the right lung hilum to the thoracic duct below the tracheal bifurcation (white arrows).

COMMENTS

The renal LN anatomical distribution area is very extensive and varies from one individual to another. The first injected LNs are laterocaval on the right and lateroaortic on the left, in the vicinity of the venous and/or renal vasculature but may also be as distant as the iliac vessels.

The role of lymphadenectomy in the surgical management of renal carcinoma still remains an area of controversy, especially as distant metastases can occur without regional nodal involvement (5). The reported incidence of LN metastases from renal cell carcinoma varies from less than 5% to more than 50% (6). This substantial disparity is likely multifactoral in origin but includes key issues such as the absence of lymphadenectomy or its extent. Even when advocated, the appropriate lymphadenectomy is difficult to define. Hilar lymphadenectomy is of limited efficacy and significance (7). Even if hilar LN metastases are present (although rare) (8), neither our injections nor prior studies (1,2,4) have demonstrated a hilar LN. Hilar metastases may correspond to involvement of lymphoid tissue the presence of which has been reported by Cunéo (4). Lymphadenectomy may be regional (7), including paracaval, retrocaval and interaortocava LNs on the right and paraaortic and retroaortic LNs on the left. This approach would remove most of the first LNs which we highlighted and, therefore, is appropriate. Lymphadenectomy may be more extensive (7), encompassing retrocaval, interaortocaval and preaortic LNs on the right and preaortic, interaortocaval and precaval LNs on the left. Even extended lymphadenectomy will not always suffice. Our study demonstrates that lymphadenectomy should be more extensive and include celiac artery and contralateral paraaortic LNs to be complete. Beyond this consideration, patterns of LN metastases are seldom predictable. A series reported by Hülten et al (9), including bilateral lymphadenectomy, demonstrated isolated distant nodal metastasis twice in the ipsilateral iliac nodes (as we observed once in injections) and once in the supraclavicular nodes.

The connections to the TD appear more noteworthy. From the injected LNs, we consistently observed lymphatic vessels ending in the TD or forming part of its origin. In many cases, we also observed lymphatic vessels directly joining the TD in the same manner without traversing any LNs. This TD connection gives rise to four implications:

First, direct passages to the TD were previously described behind the crura and more particularly along the sympathetic nerves (1,4). We also observed these retrocrural pathways but they were inconsistent, occurred at any level, and were not associated with the sympathetic nerves. We also observed that the lymphatic vessels generally joined the TD by passing upwards along the posterior aspect of the aorta between both diaphragmatic crura, which to our knowledge has not been previously described.

Second, distant renal cancer metastases can occur without LN involvement (10). This event may be misinterpreted as hematogenous spread of renal cell carcinoma and attributed to inferior vena cava invasion. Our study demonstrates that metastatic cells could directly enter the blood circulation connection via the TD to the superior vena cava (lymphogenous) thereafter contributing to hematogenous spread. Pantuck et al (11) reported similar survival for individuals who were N+M0 and those who were N0 M+ in the lung, and individuals with both gross nodal disease and distant metastasis carried the worst prognosis. Our data suggest that isolated LN involvement or isolated lung involvement may have the same significance and reflect tumor cells draining via lymphatic vessels and stopped either by the LN or by the lung when renal lymph drainage directly enters the TD.

Third, the TD receives many tributaries from the lungs, and peritracheobronchial LNs are connected to the TD within the mediastinum (12). In the case of lymphatic valvular incompetency, tumor cells traveling within the TD may reflux and seed within the mediastinal LNs. Direct renal lymph drainage to the TD without LNs interposed in the pathways may explain the more frequent occurrence of isolated mediastinal LN metastasis observed in renal cancer compared to tumors arising in other organs (13). This feature may also explain the rare intrapulmonary lymph node metastases observed in the absence of lung or mediastinal LN metastases (14). One of our observations (*Fig. 8*) supports the hypothesis of reflux from the TD toward the lung hilum explaining the pathogenesis of such LN metastases originally described by Wright (14).

Finally, direct connections of both kidneys to the thoracic duct explains the occurrence of chyluria by chylous reflux into the renal lymphatics in pathologic states characterized by central lymphatic valvular insufficiency. This observation can also explain the occurrence of chyloperitoneum following nephrectomy when injured lymphatic vessels develop valve incompetency and further, supports the need for clipping all "vascular structures" during nephrectomy as recommended by Wilson et al (15).

CONCLUSION

Renal lymphatics often flow directly toward paraaortic LNs far from the injected kidneys (aortic bifurcation, coeliac or mesenteric LNs, and contralateral LNs). They consistently terminate in the TD, sometimes directly without crossing through any LNs, which supports their important contribution to origin of the TD and subsequent "hematogenous" spread of renal cancer via the superior vena cava.

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