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Light chain deposition disease of the kidney. Morphological aspects in 24 patients

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Abstract Renal biopsies and autopsy specimens of 23 patients with light chain deposition disease (LCDD) and one with only heavy chain deposits, were studied by light (LM) and electron microscopy (EM) as well as immunohistology (IH). Thirteen patients had multiple myeloma; 1 had lymphoma, and 1 chronic myeloid leukaemia with polycythaemia vera. In nine patients, no lymphoproliferative disease was identified. The LM lesions most suggestive of LCDD, nodular glomerulosclerosis (NS) and thickening and wrinkling of the tubular basement membranes (TBM), were present in only ten and 13 patients, respectively. In five of seven specimens without NS or TBM thickening by LM, EM was negative, indicating a limited value of EM in confirming the diagnosis. Renal amyloidosis was not identified, but in one patient amyloid in the heart and tongue was seen at autopsy. One patient had both granular and extensive glomerular non-amyloid fibrillary deposits. In two patients myeloma casts were identified. Twenty-one patients showed renal LC immune reactivity, 1 had both alpha heavy and lambda LC, 1 had only detectable gamma heavy chain. One biopsy was negative by IH, but had characteristic electron dense deposits. In six patients with immune reactivity to LC, no electron dense deposits could be identified by EM. This study emphasizes the spectrum of renal changes by LM and EM in LCDD, the frequent lack of consistency between deposits detected by IH and EM and the difficulty in coming to a definite diagnosis without LM, EM and IH. The results of this study and examination of the literature indicates that extensive morphological changes are more often present in kappa than in lambda LCDD.

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Light chain nephropathy · Myeloma · Myeloma kidney

Introduction

Light chain deposition disease (LCDD) is a systemic disorder characterized by deposition of monotypic immunoglobulin LC in several organs [23]. The disease usually occurs in patients with plasma cell dyscrasias or other lymphoproliferative diseases, but many cases are reported to occur unassociated with a defined underlying disease [10].

The kidney is the organ most affected clinically, resulting in proteinuria and chronic or rapidly progressive renal failure [10] [Pozzi et al. (submitted)]. Since morphological findings by light microscopy (LM) often are non-characteristic, the diagnosis is based on the demonstration of monotypic LC by immunohistology (IH) or typical granular osmiophilic deposits by electron microscopy (EM). The morphological pattern of LCDD has often been presented as case reports or in small series of patients, and only recently has a larger series of patients been reported [5, 10, 11] with 14, 15 and 19 patients respectively.

In this report we describe the renal morphology in 23 patients with LCDD and one where only gamma heavy chains were detected. The distribution of the immune reactivity as well as the electron dense deposits will be described in detail. We emphasize the spectrum of glomerular changes by LM, the systemic involvement and the frequent discrepancies between IH findings and deposits found by EM.

Materials and methods

Twenty-three patients with LCDD and one with only detectable heavy chain deposits were studied. They comprised 16 men and 8 women, aged from 33 to 80 years, observed at Italian renal units in Milan and Lecco (21 patients) and in Switzerland (3 patients) between 1985 and 1993. The patients were selected on the basis of

linear monotypic LCD by IH and/or granular deposits by EM on glomerular basement membrane (GBM) and/or tubular basement membrane (TBM) in renal specimens. In two patients (cases 4 and 13), repeat biopsies were available. In one patient (case 7), biopsy and autopsy were studied. In one case, only autopsy material was studied, giving a total of 27 specimens. Clinical aspects and response to treatment in 17 of these patients are presented elsewhere [Pozzi et al. (submitted)].

Formalin-fixed renal specimens were processed for LM (all cases) and glutaraldehyde-fixed specimens for EM (24 specimens) according to standard procedures [31]. One to four glomeruli from each biopsy were studied by EM. For LM, the biopsies were stained with periodic acid-Schiff (PAS), acid fuchsin orange G (AFOG), silver-methenamine and Congo red.

For IH, formalin-fixed material was studied. In 23 specimens, immunofluorescence was performed according to Fogazzi et al. [8]. In three, the avidin-biotin complex (ABC) technique was employed, using the ABC Elite kit (Vector, Burlingame, Calif., USA). Polyclonal rabbit anti-human antiserum against immunoglobulins and LC were used (Dakopatts, Glostrup, Denmark). In one case, immuno-EM was performed on glutaraldehyde fixed Epon embedded material according to Ihling et al.

Each specimen was evaluated for the presence of "suggestive lesions for LCDD" by LM, defined as glomerular nodular sclerosis and ribbon-like refractile appearance of TBM thickening, often with multilayering in the tubules. Based on the presence of these lesions, the cases were separated into four groups A–D (see Tables); A, glomerular and tubular lesions (nine specimens); B, glomerular only (three specimens); C, tubular only (six specimens) and D, no suggestive lesions (nine specimens). Since lesions in the extraglomerular tissues are important in this disease, tubules, interstitial tissue and vessels were studied extensively.

We also reviewed the reports on those larger series of patients published previously to investigate whether certain morphological changes could be related to the type of LC involved.

Results

The clinical findings are summarized in Table 1.

Light microscopy

In this series of 27 specimens, 10 showed normal glomeruli (Table 2). In 12 biopsies, NS was present in 12%–100% of the glomeruli (Fig. 1). Five of these specimens showed a pattern of membranoproliferative glomerulonephritis (MPGN), and had cellular crescents (Fig. 2), affecting less than 10% of glomeruli in three specimens and 28% and 50%, respectively, in two. Capillary aneurysms were identified in these cases and were quite prominent in those with most crescents (Fig. 3). Two of the specimens with NS exhibited a pattern of mesangial proliferative glomerulonephritis (MGN). One specimen showed a mild MGN only, and in four diffuse mesangial enlargement was the dominent pattern (Fig. 4). Obsolescent glomeruli were invariably present (17%–40% of glomeruli).

Table 1 Clinical findings in light chain deposition disease (LCDD)

Group	Patient number	Sex female (*f*) male (*m*)	Age (years)	Plasma creatinine at biopsy (mg/dl)	Proteinuria at biopsy (g/24 h)	Lymphoproliferative disease	Follow up (months)/ creatinine at end/ dead (*d*) or alive (*a*)
A	1	f	64	5.8*	2	myeloma	3/dialysis/d
	2	f	53	6.2*	3.5	myeloma	53/3.5/a
	3	m	54	7.4	4.6	none	37/dialysis/d
	4	m	52	2.8	Absent	none	82/5.3/d
	5	f	33	2.4	12.9	myeloma	33/2.6/d
	6	m	62	3.6	11	myeloma	1/3.7/a
	7	m	47	17*	7.3	none	4/dialysis/d
B	8	m	77	2.3	4	none	6/5.0/d
	9	m	54	2.0*	10.4	myeloid leukaemia/ Polycythaemia	14/dialysis/a
	10	m	53	2.1	2.0	vera, lymphoma	32/1.9/a
C	11	f	59	7.6*	0.5	myeloma	2/dialysis/d
	12	f	51	4.4*	1.7	myeloma	10/dialysis/d
	13	m	58	2.7*	3.7	myeloma	21/2.2/d
	14	m	66	9.5*	Absent	none	6/dialysis/d
	15	m	73	3.7	1.3	none	25/3.4/a
	16	m	80	5.8	Absent	none	13/6.5/a
D	17	f	64	6.9*	1.2	myeloma	11/7.0/d
	18	m	42	2.8*	8	myeloma	6/2.0/d
	19	m	64	4.1*	3.4	myeloma	8/1.8/d
	20	f	67	2.6*	4.9	myeloma	7/dialysis/d
	21	m	44	2.4*	30	myeloma	34/dialysis/d
	22	m	73	7.3*	0.5	none	2/3.6/d
	23	m	33	1.4	17	none	2/3.5/d
	24	f	56	2.0	>16	myeloma	8/dialysis/d

* Rapid renal function deterioration

Table 2 Light microscopical changes and type of deposit in LCDD (*k* kappa, *l* lambda), *ME* mesangial expansion, *MGN* mesangial proliferative glomerulonephritis, *MPGN* membranoproliferative glomerulonephritis, *n.a.* not available, *NS* nodular sclerosis

Group	Patient number	Duration before biopsy (months)	Type of light chain deposit	Glomeruli		
				Morph.	NS %	Cresc. %
A	1	1	k	MPGN/NS	70	10
	2	36	k	ME/NS	42	
	3	22	k	Collapse/NS	20	
	4a	1	k	MGN/NS	20	
	4b	50	k	MGN/NS	12	
	5	33	k	NS	75	
	6	n.a.	k	NS	60	
	7a	1	k	MPGN/NS	17	50
	7b	4	no IF	NS	100	
B	8	9	k	MPGN/NS	33	9
	9	n.a.	k	MPGN/NS	28	28
	10	n.a.	gamma (k in serum)	MPGN/NS	73	3
C	11	12	k	ME		
	12	1	k	ME		
	13b	18	k	normal		
	14	3	k	normal		
	15	7	l	ME		
	16	28	k	normal		
D	17	3	k	normal		
	18	1	l	normal		
	19	1	l and alpha	normal		
	20	9	k	ME		
	21	2	l	normal		
	22	1	l	MGN		
	23	2	l	normal		
	24	2	none (IgG-I) in serum)	normal		
	13a	1	k	normal		

In 15 specimens, thickening, wrinkling and/or multilayering of the TBM was present (Fig. 5), mostly around atrophic, and to a lesser extent around non-atrophic, tubules. In some biopsies without clear-cut TBM thickening, a brighter stain or glassy appearance of the TBM was noted in the PAS stain. In the AFOG stain the TBMs were strongly blue. In two patients, typical glassy, fractured myeloma casts with foreign body reaction were seen. One patient had peculiar crystalline fragmentation of casts. The latter three patients had myeloma clinically.

All biopsies except one showed interstitial fibrosis ranging from mild (14 specimens) to moderate (9 specimens) and severe (3 specimens). A focal pattern was often observed. The degree of fibrosis correlated with the number of obsolescent glomeruli or with nodular sclerosis. Lymphoplasmocytic infiltrates were found in 11 biopsies. Most often a mild focal distribution of the inflammatory infiltrate was seen. Plasma cells were never prominent.

In specimens 1, 3 and 11, PAS positive deposits were seen outlining the myocytes in arterial and arteriolar walls. Specimen 7 had extensive hypertensive changes of vessels with arteriolar wall necrosis, thrombus-formations and occlusion of the vessel lumen.

All specimens were Congo red negative.

IH

By IH, kappa LC were detected in 17 patients and lambda in 5 (Table 2). One (case 19) had immune reactivity to both IgA and lambda LC. In a patient (case 10) with monoclonal IgG-kappa in serum, only gamma heavy chain without detectable LC, was seen in the deposits. Another patient (case 24) with IgG-lambda in serum and positive EM, was negative by IH, only casts were lambda positive. All specimens but one showed linear deposits along the TBM, 18 along the GBM, 12 in the mesangium and 12 along the BM of Bowman's capsule (Table 3). Fifteen had immune reactivity along vascular structures (Fig. 6), and 8 specimens showed scattered granular interstitial fluorescence.

Only one biopsy had deposits in all the recorded sites of the renal tissue. Most often immune reactivity was identified in three or four sites. The intensity of the immune reactivity varied between cases, and was sometimes very weak and not widely distributed. In only two cases with positive fluorescence along the TBM, were the glomeruli negative. None of the cases had the combination of positive glomeruli and negative tubules.

Igs and complement were generally not detectable. However, in a few cases with NS, weak focal IgM and C_3 were seen in the mesangial nodules.

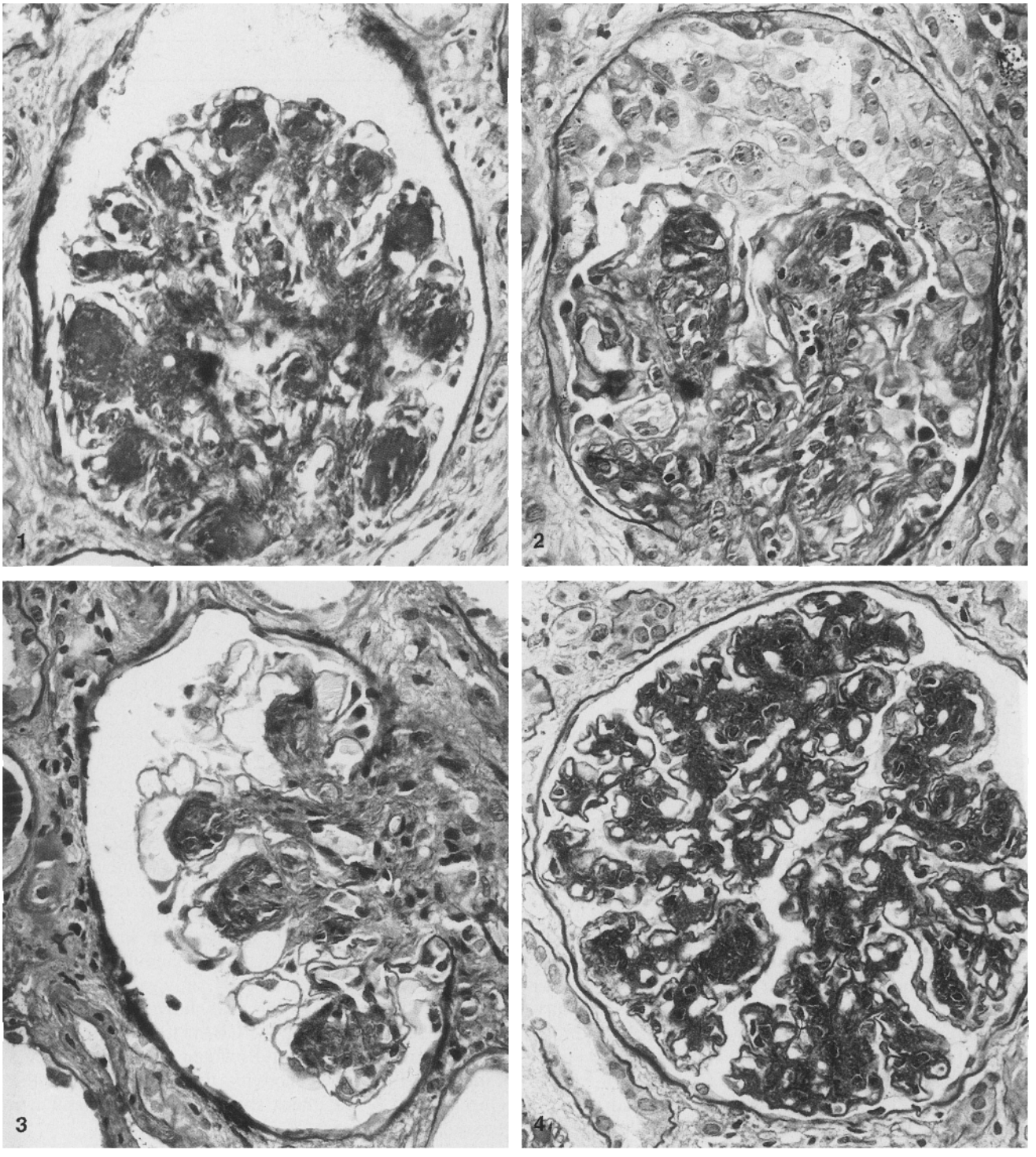


Fig. 1 Nodular glomerulosclerosis without lamellation of mesangium [periodic acid-Schiff (PAS) ×340]

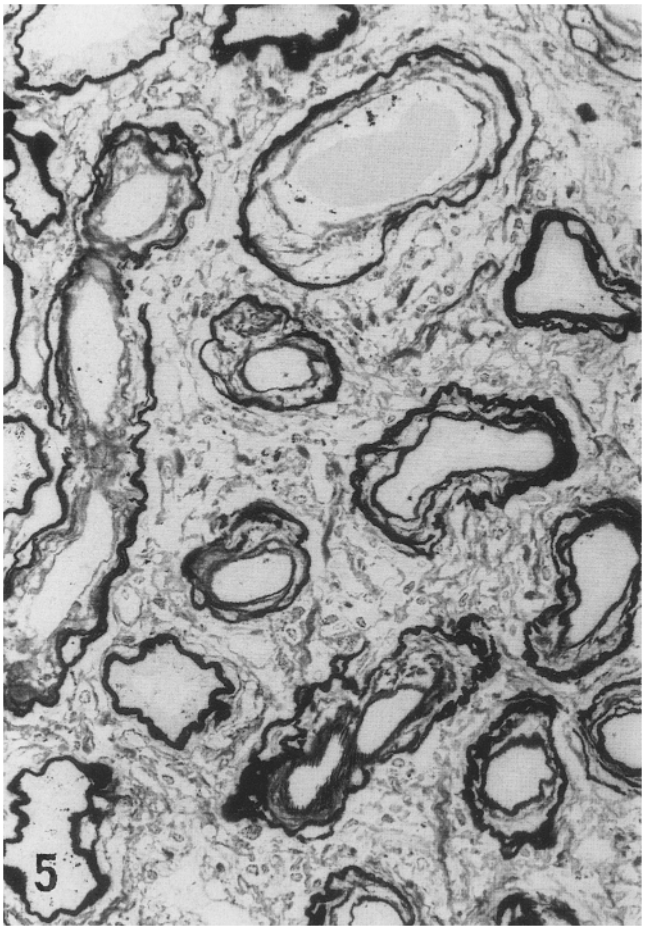
Fig. 2 Membranoproliferative glomerulonephritis-like lesion with crescent. (PAS, ×340)

Fig. 3 Capillary aneurysms. (PAS, ×340)

Fig. 4 Diffuse mesangial enlargement. (PAS, ×340)

Electron microscopy

Of 24 specimens studied in 22 patients, 12 showed deposits both in glomeruli (Fig. 7, 8) and TBM (Fig. 9). Deposits in the glomeruli without TBM deposits were seen in five biopsies, deposits in TBM without glomerular deposits were never seen. In the majority of cases, glomerular deposits were both in the glomerular basement membranes (GBM) and in the mesangium (Table 4). Two specimens had positive GBM and negative



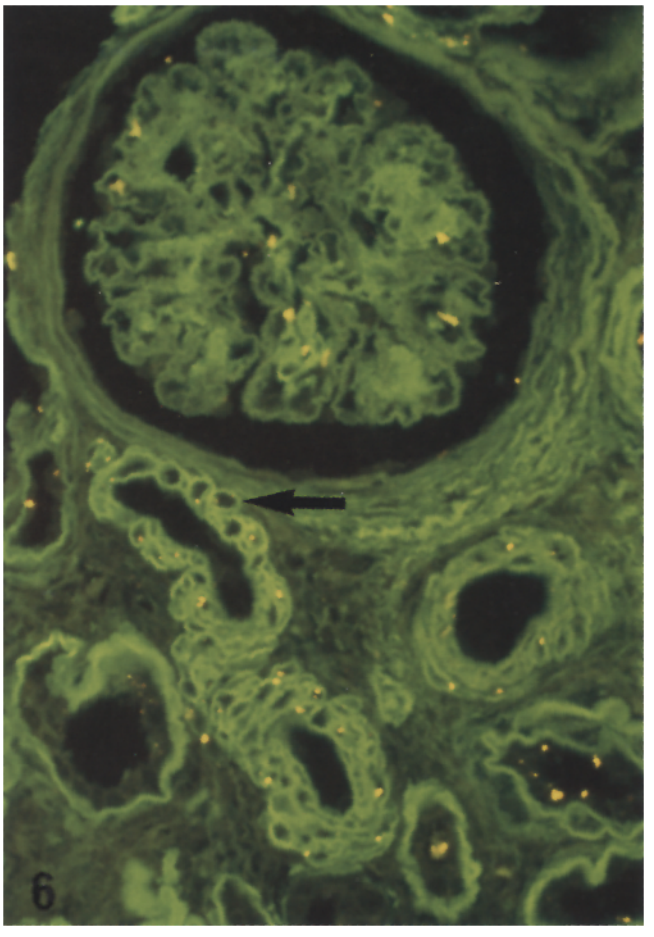


Fig. 5 Thickening and multilayering of tubular basement membranes. (silver-methenamine, ×340)

Fig. 6 Strong immune reactivity to kappa in tubular basement membranes and arteriole, outlining myocytes (*arrow*). Weaker immune reactivity in glomerular basement membrane and mesangium. (Immunofluorescence, ×170)

mesangium, and only one had a positive mesangium and negative GBM. In the nodularly transformed glomeruli, osmiophilic deposits were regularly present in the mesangium (Fig. 7). Seven specimens (29,2%) had no osmiophilic deposits in any structure.

Table 3 Localization of deposits by immunohistology in LCDD (*Mes* mesangium, *GBM* glomerular basement membrane, *BC* Bowman's capsule, *n* number of cases *N* total cases)

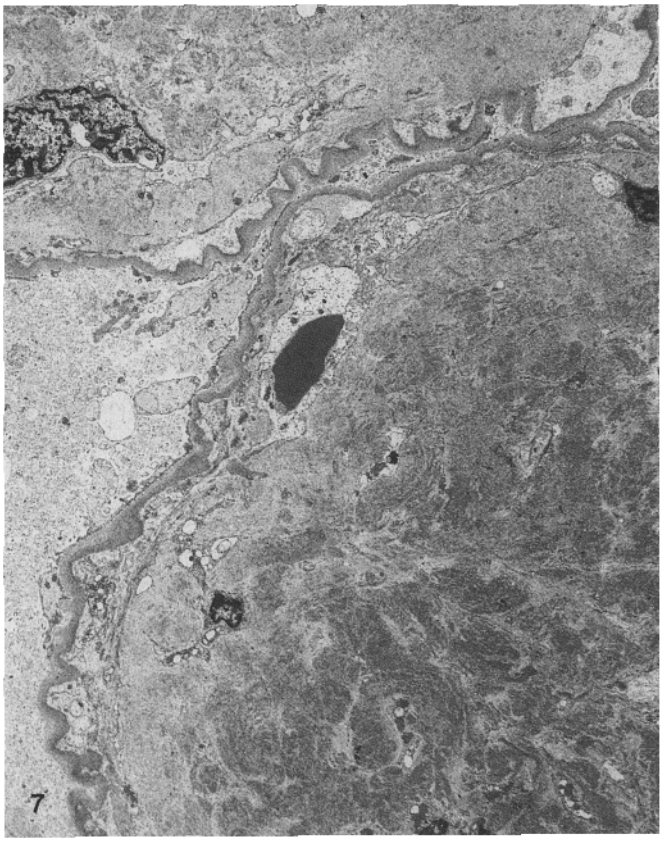
Localization		Specimens (n/N)
Glomeruli	GMB+Mes	6/25
	GBM+BC	6/25
	GBM only	4/25
	Mes+BC	3/25
	GBM+Mes+BC	2/25
	Mes only	1/25
	BC only	1/25
	No reactivity	2/25
Tubules		25/26
Vessels		15/26
Interstitium		8/26

Only 11 of the 24 samples for EM evaluation contained arteries or arterioles, and 8 of them had deposits around myocytes. In 7 out of 15 samples the interstitial capillaries showed deposits in the pericapillary BM (Fig. 10). Interstitial deposits were demonstrated in 11 specimens. One biopsy with positive GBM, TBM and Bowman's capsular BM by IH, had only weak, focal deposits by EM. These would probably have been overlooked without knowledge of the immunofluorescence findings.

One patient (case 11) with granular deposits in TBM, GBM and arterioles, had massive mesangial and subendothelial short, curved non-amyloid fibrils with a diameter of 6–8 nm (Fig. 11). Fibrils were also identified in the walls of interstitial capillaries (Fig. 12).

In the glomeruli, the deposits were most often seen on the inner aspects of GBM, the lamina rare externa was seldom affected (Fig. 8). Non-specific thickening of the lamina rara interna was frequent. Coarse granules were evenly distributed along the GBM, but in some cases only some loops were affected. In the mesangium, especially in the nodularly transformed glomeruli, the deposits were not as dense as in the GBM and were often aggregated in lumps coexistent with increased mesangial matrix (Fig. 7). Segmental effacement of podocytic foot processes was frequently observed.

In the TBM the deposits were most often located on the outer aspects. Lamellation of the deposits was frequently observed, where different layers had varying



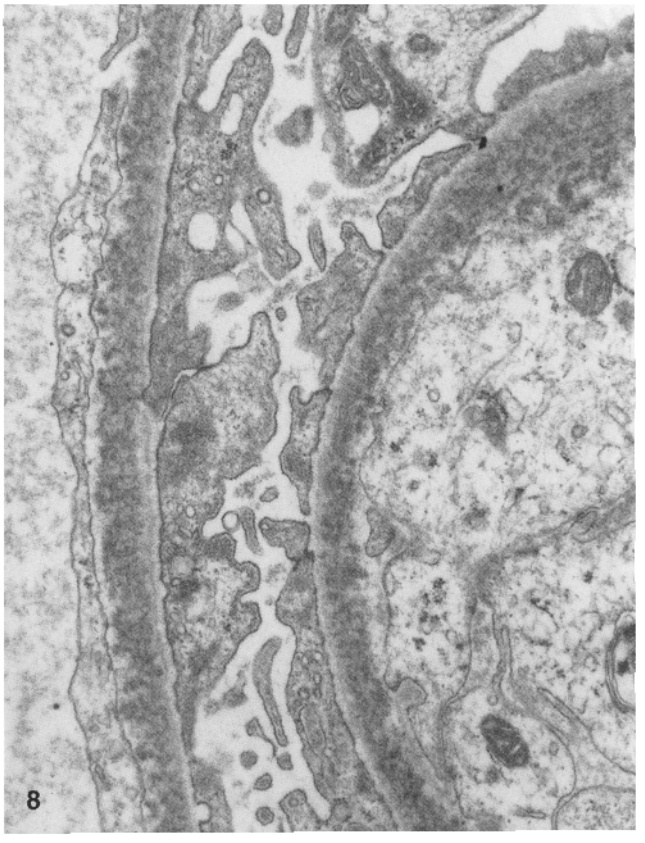
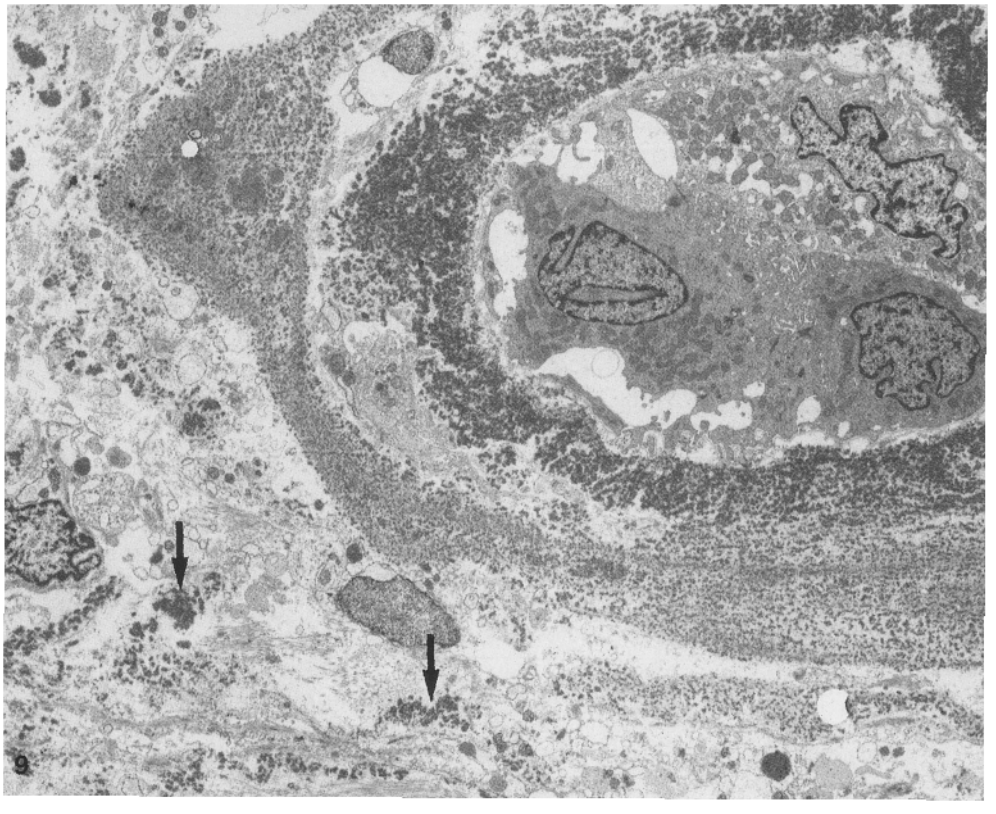


Fig. 7 Nodular mesangial sclerosis with numerous strongly osmiophilic deposits. The capillary lumens are narrowed. Deposits are also noted on the inner aspects of the wrinkled glomerular basement membrane. [Electron microscopy (EM) ×2575]

Fig. 8 Granular deposits affecting the inner layer of the glomerular basement membrane. Parts of the outer lamina densa and the lamina rara externa are not affected. (EM, ×21460)

Fig. 9 Atrophic tubule surrounded by multilayered basement membrane containing granular deposits of different osmiophilia. Lumps of deposits in the interstitium (*arrows*). (EM, ×3863)



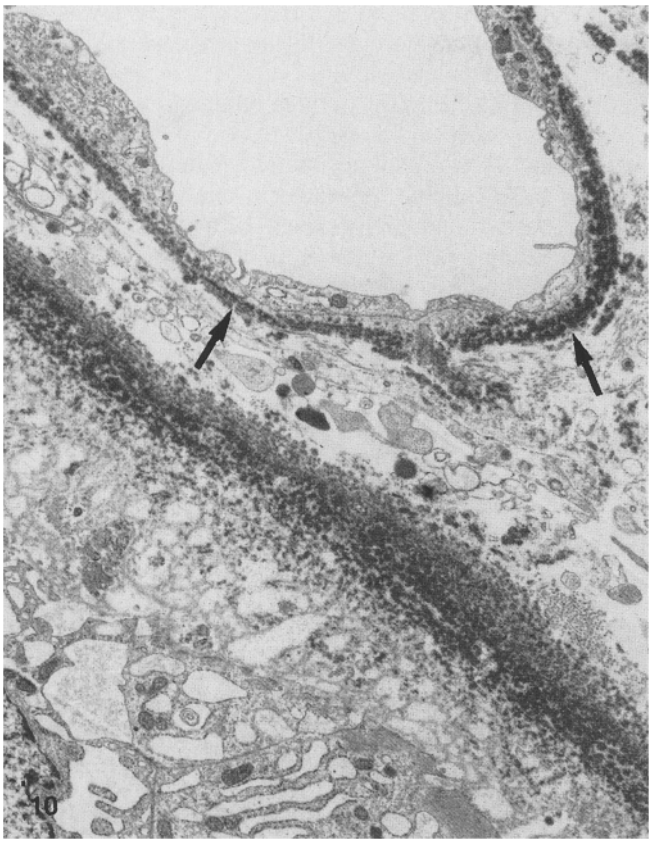
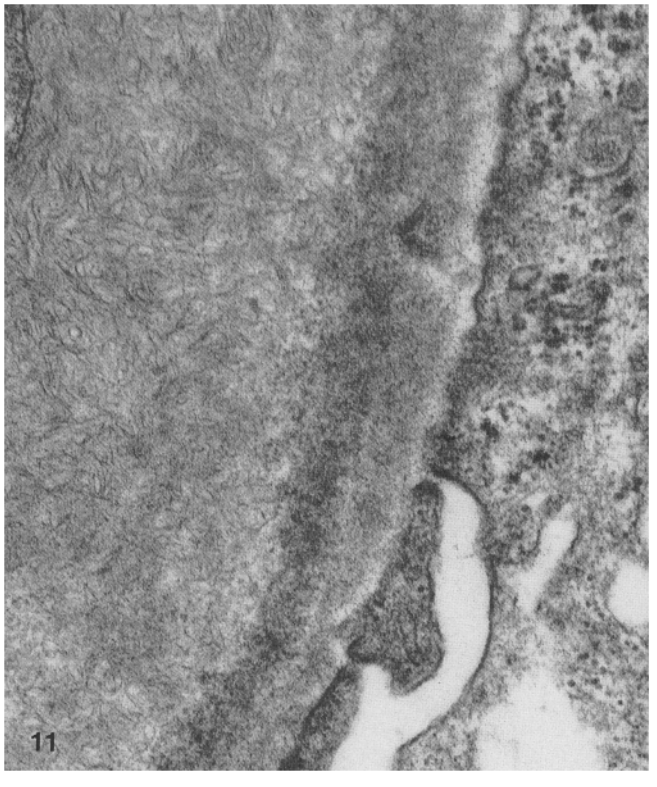


Fig. 10 Highly osmiophilic granular deposits in the pericapillary basement membrane (*arrows*) and tubular basement membrane. (EM, ×8369)

Fig. 11 Non-amyloid fibrillar deposits in the mesangium and granular deposits in the glomerular basement membrane. (Patient number 11; EM, ×42920)

Fig. 12 Non-amyloid fibrillar deposits in severly thickened pericapillary basement membrane. *E* endothelial cell. (Patient number 11; EM ×42920)



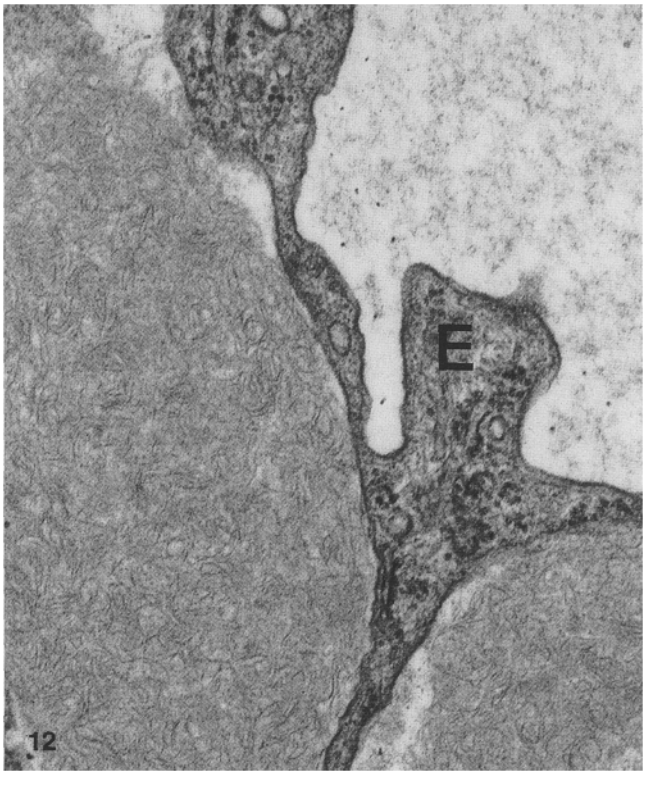


Table 4 Localization of osmiophilic dense deposits by electron microscopy in LCDD

Localization		Specimens (n/N)
Glomeruli	Mes+GBM+BC	10/24
	Mes+GBM	4/24
	GBM only	2/24
	Mes+BC	1/24
	no deposits	7/24
Tubules		12/24
Interstitial capillaries		7/15
Arteries or arterioles		8/11
Interstitium		11/24

density of the granules (Figs. 9, 10). In the interstitium the deposits were lumped together and observed only in a few places (Fig. 9).

By immune EM performed on specimen 23, condensation of gold particles were seen overlying the GBM with antibodies to IgG, but no reaction was noted with antibodies to LC.

Additional findings

Comparison between EM and IH (Table 5) showed that in 11 cases the two methods gave comparable results. In ten cases, IH was more sensitive, while EM was more sensitive in only one case. In another case EM showed glomerular deposits only, while IH was positive only along the TBM. Finally, in three other cases, no comparison was possible since one of the two methods could not be applied. In two patients autopsy material from several organs was available for study. In one case granular deposits were found in the liver, heart, spleen and eye, mainly along vessel walls. In another, amyloid was observed in the heart and tongue. No morphologic pattern distinguished between patients with or without myeloma or with short (<7 months) or long (>20 months) survival.

The relationship between the type of LC involved and the presence of certain morphological changes are summarized in Tables 5 and 6. NS and TBM deposits were more frequently observed in kappa than in lambda involvement ($P<0.03$ and 0.007, respectively). Glomerular osmiophilic deposits were also more frequent, however not significantly, in cases of kappa LCD.

Discussion

In LCDD a wide variety of histological features are found. In our study 56% of specimens did not show NS, the glomerular lesion considered to be the most sugges-

Table 5 Comparison of the distribution of deposits by electron microscopy (*EM*) and immunohistochemistry (*IH*)

Group	Patient number	Type of deposit	EM		IH	
			glomeruli	tubules	glomeruli	tubules
A	1	k	+	+	+	+
	2	k	+	+	+	+
	3	k	+	+	+	+
	4a	k	+	–	+	+
	4b	k	(+)	–	++	
	5	k	+	+	+	+
	6	k	+	+	n.a. (medulla)	+
	7a	k	+	+	+	+
	7b		No EM		No IH	
B	8	k	+	+	+	+
	9	k	+	(+)	+	+
	10	gamma (k in serum)	+	+	+	+
C	11	k	+	+	+	+
	12	k	+	+	+	+
	13b	k	–	–	+	+
	14	k	+	–	–	+
	15	l	(+)	–	+	+
	16	k	–	–	+	+
D	17	k	–	–	+	+
	18	l	–	–	+	+
	19	I and alpha	No EM		+	+
	20	k	+	+	+	+
	21	l	–	–	–	+
	22	l	No EM		+	+
	23	l	–	–	+	+
	24	none (IgG-I in serum)	+	–	–	–
	13a	k	–	–	+	+

Table 6 Morphological changes related to type of LC as reported in the literature and in the present study (*TBM* tubular basement membrane, *NS* nodular sclerosis)

Author	Light chain	Light microscopy	EM	
		NS (n/N)	TBM deposits (n/N)	Glomerular deposits (n/N)
Noël et al. [19]	k	5/10	4/10	6/10
	l	0/1	0/1	0/1
Pirani et al. [21]	k		8/8	8/8
	l		2/2	2/2
Confalonieri et al. [5]	k	6/11	8/8	8/8
	l	0/2	1/1	1/1
Buxbaum et al. [4]	k	2/9	7/9	6/9
	l	1/4	1/4	2/4
Ivanyi et al. [13]	k	3/6	5/5	4/5
	l	1/1	1/1	1/1
This study	k	10/17	12/17	14/17
	l	0/7	0/5	2/5
Total	k	26/53=49.1%	44/57=77.2%	46/57=80.7%
	l	2/15=13.3%	5/14=35.7%	8/14=57.1%
significance		$P<0.03$	$P<0.007$	$P<0.13$

tive of LCDD [10]. Not all laboratories routinely use LC antibodies, and, by EM, the characteristic deposits may be scattered and minimal, especially in the early stage of the disease. All these factors may result in an underestimation of the frequency of LCDD.

Glomerular hypercellularity, especially with a pattern of MPGN, is frequently found in LCDD. However, glomerulonephritis with crescents, as reported in individual cases [17, 25], is not held to be common. In our material, however, almost 20% of the patients had crescents. In two of these, the crescents affected 28% and 50% of the glomeruli, respectively. In one patient (case 7a), who had severe hypertensive arteriolar hyalinosis, the crescents were global. In cases with crescents, prominent capillary aneurysms were present as well. With such severe and proliferative pathology, a diagnosis of LCDD would probably not be considered if complete IH or EM is not performed. Cellular crescents affecting a minority of glomeruli, were seen in another three of our patients, and this is probably not unusual in LCDD [5]. Aneurysmally dilated capillary loops, as seen in five of the patients, have been demonstrated in several diseases with nodular transformation of glomeruli, such as LCDD [21, 27], idiopathic lobular GN [1] and fibrillary GN [7].

Different manifestations of LCD at the same time in the kidney are not common [10] Lam and Chan [16] reported the highly unusual constellation of renal amyloidosis, cast nephropathy and LCDD in one patient. The combination of amyloid and LCDD is also rare [14, 15]. None of our patients had renal amyloidosis, although in one, amyloid deposits in the tongue and heart were disclosed at autopsy. Only two patients had myeloma casts.

Typical granular deposits of LCDD in association with minor non-amyloid fibril formations are reported in a few cases [18, 19, 20, 26]. However, LCDD associated with extensive non-amyloid fibrillar deposits in glomeruli and around capillaries, as demonstrated in specimen 11, has not been described previously. The molecular characteristics of LC responsible for the different types of tissue deposition [amyloid, casts, granules (LCDD), crystals, fibrils] have not been clarified [28]. It has been suggested that various physico-chemical properties of the individual LD or local factors in the tissue account for the different morphological patterns of tissue deposition [4].

The systemic nature of LCDD has previously been well documented [6, 23]. At autopsy, one of our patients had widespread extrarenal deposits, including in the eye [Daicker et al. (submitted)].

Positive immune findings in the absence of electron dense deposits are well known in human beings, and are also reported in experimental studies [28]. In our series, seven specimens had positive findings by IH, but lacked osmiophilic deposits by EM. This may possibly be explained by differences in LC structure; not all LC types form electron dense deposits. In some cases it is also possible that the electron dense deposits are more focally distributed and not always present in the small tissue samples available for EM study. Interestingly, of these seven specimens only two lacked suggestive lesions by LM. These findings indicate that LC forming granular dense deposits detectable by EM are a prerequisite for the development of NS and characteristic TBM changes.

Certain differences in the morphology of kappa and lambda LC nephropathy, were noted by Tubbs et al. [29]. Our study, including the literature review, show that extensive morphological changes by LM and EM are more often present in kappa LC nephropathy than in lambda LC nephropathy.

Of seven specimens (where EM was performed) without suggestive lesions on LM, only two had osmiophilic deposits by EM. Moreover, of the 17 specimens (where EM was performed) with suggestive lesions, only 2 lacked deposits on EM. This indicates that in the absence of NS or TBM thickening by LM, EM will often not contribute to the diagnosis of LCDD.

The lack of immune reactivity in structures positive by EM, is also well known [3, 5, 21]. One of our patients (case 24) had no detectable LC by IH, but the GBM had characteristic granular deposits by EM. Another patient (case 14) had deposits in the glomeruli by EM, but these were negative by IH, although the TBM, vessel and interstitial tissue showed fluorescence. These findings could be explained by a structural change of the antigenic sites on the LC forming granular deposits, masking the epitopes for antibody recognition [22]. The lack of detectable LC in our patient (case 10) with gamma heavy chain deposition only, who had monoclonal IgG-kappa in serum, can possibly be explained in the same way. The term pseudo-gamma heavy chain deposition disease has been suggested for this condition [30]. However, granular deposition of heavy chains alone has only been convincingly documented on rare occasions [2]. Simultaneous deposition of monoclonal LC and heavy chains, as seen in one of our patients with alpha-lambda deposits, has been described in several patients [4, 5].

Our study supports the view that both EM and IH should be performed in order to make a reliable diagnosis of LCDD. IH is probably a more sensitive method, but weak or lack of immune reactivity in biopsies where electron dense deposits are present emphasizes the value of EM in this disease.

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References

1. Alpers CE, Biava CG (1989) Idiopathic lobular glomerulonephritis (nodular mesangial sclerosis): a distinct diagnostic entity. Clin nephrol 32:68–74
2. Aucouturier P, Khamlichi AA, Touchard G, Justrabo E, Cogne M, Chauffert B, Martin F, Preud'homme J-L (1993) Brief report: heavy-chain deposition disease. N Engl J Med 329: 1389–1393
3. Bangerter AR, Murphy WM (1987) Kappa light chain nephropathy. Virchows Arch [A] 410:531–539
4. Buxbaum JN, Chuba JV, Hellman GC, Solomon A, Gallo GR (1990) Monoclonal immunoglobulin deposition disease: light chain and light and heavy chain deposition diseases and their relation to light chain amyloidosis. Ann Intern med 112: 455–464
5. Confalonieri R, Barbiano di Belgiojoso G, Banfi G, Ferrario F, Bertani T, Pozzi C, Casanova S, Lupo A, De Ferrari G, Minetti L (1988) Light chain nephropathy: histological and clinical aspects in 15 cases. Nephrol Dial Transplant 2:150–156
6. Droz D, Noël LH, Carnot F, Degos F, Ganeval D, Grünfeld JP (1984) Liver involvement in nonamyloid light chain deposits disease. Lab Invest 50:683–689
7. Esparza AR (1991) Fibrillary (immunotactoid) glomerulopathy. A possible role for kappa light chain in its etiology and/or pathogenesis. Am J Surg Pathol 15:632–643
8. Fogazzi GB, Bajetta M, Banfi G, Mihatsch MJ (1989) Comparison of immunofluorescent findings in kidney after snap-freezing and formalin fixation. Pathol Res Pract 185:225–230
9. Ganeval D, Mignon F, Preud'homme JL, Noël LH, Morel-Maroger L, Droz D, Brouet JC, Mery JP, Grünfeld J-P (1982) Visceral deposition of monoclonal light chains and immunoglobulins: a study of renal and immunopathologic abnormalities. Adv Nephrol 11:25–63
10. Ganeval D, Noël L-H, Preud'homme J-L, Droz D, Grünfeld J-P (1984) Light-chain deposition disease: its relation with AL-type amyloidosis. Kidney Int 26:1–9
11. Heilman RL, Velosa JA, Holley KE, Offord KP, Kyle RA (1992) Long-term follow-up and response to chemotherapy in patients with light-chain deposition disease. Am J Kidney Dis 20:34–41
12. Ihling Ch, Olivieri V, Banfi G, Fogazzi GB, Edefonti A, Gudat F, Mihatsch MJ (1994) Immunoelectron microscopy of different forms of glomerulonephritis in routine biopsy matieral. Pathol Res Pract
13. Ivanyi B, Varga G, Nagy J, Berkessy S, Keresztury S (1991) Light chain deposition nephropathy in necropsy material. Zentralbl Allg Pathol 137:366–371
14. Jacquot C, Saint-Andre J-P, Touchard G, Nochy D, D'Auzac de Lamartinie C, Oriol R, Druet P, Bariety J (1985) Association of systemic light chain deposition disease and amyloidosis: a report of three patients with renal involvement. Clin Nephrol 24:93–98
15. Kirkpatrick CJ, Curry A, Galle J, Melzner I (1986) Systemic kappa light chain deposition and amyloidosis in multiple myeloma: novel morphological observations. Histopathology 10:1065–1976
16. Lam KY, Chan KW (1993) Unusual findings in a myeloma kidney: a light- and electron-microscopic study. Nephron 65:133–136
17. Lapenas DJ, Drewry SJ, Luke RL, Leeber DA (1983) Crescentic light-chain glomerulopathy. Report of a case. Arch Pathol Lab Med 107:319–323
18. Linder J, Croker BP, Vollmer RT, Shelburne J (1983) Systemic kappa light-chain deposition. Am J Surg Pathol 7:85–93
19. Noël LH, Droz D, Ganeval D, Grünfeld JP (1984) Renal granular monoclonal light chain deposits: morphological aspects in 11 cases. Clin Nephrol 21:263–269
20. Pelletier G, Fabre M, Attali P, Ladouch-Badre A, Ink O, Martin E, Etienne J-P (1988) Light chain deposition disease presenting with hepatomegaly: an association with amyloid-like fibrils. Postgrad Med J 64:804–808
21. Pirani CL, Silva F, D'Agati V, Chander P, Striker LMM (1987) Renal lesions in plasma cell dyscrasias: ultrastructural observations. Am J Kidney Dis 10:208–221
22. Preud'homme JL, Morel-Maroger L, Brouet JC, Cerf M, Mignon F, Guglielmi P, Seligman M (1980) Sysnthesis of abnormal immunoglobulin in lymphoplasmacytic disorders with visceral light chain deposition. Am J Med 69:703–710
23. Randall RE, Williams WC, Mullinax F, Tung MY, Still WJS (1976) Manifestations of systemic light chain deposition. Am J Med 60:293–299
24. Seligmann M (1980) Synthesis of abnormal immunoglobulin in lymphoplasmacytic disorders with visceral light chain deposition. Am J med 69:703–710
25. Silva FG (1980) Proliferative glomerulonephropathy in multiple myeloma. J Pathol 130:229–236
26. Silver MM, Hearn SA, Ritchie S, Slinger RP, Sholdice JA, Cordy PS, Hodsman AB (1986) Renal and systemic kappa light chain deposits and their plasma cell origin identified by immunoelectron microscopy. Am J Pathol 122:17–27
27. Sinniah R (1985) Glomerular capillary aneurysms in light chain nephropathy. Am J Pathol 118:298–305
28. Solomon A, Weiss DT, Kattine AA (1991) Nephrotoxic potential of Bence Jones proteins. N Engl J Med 324:1845–1851
29. Tubbs RR, Gephardt GN, McMahon JT, Hall PM, Valenzuela R, Vidt DG (1981) light chain nephropathy. Am J Med 71:263–269
30. Tubbs RR, Berkley V, Valenzuela R, McMahon JT, Gephardt GN, Fishleder AJ, Nally JV, Pohl MA, Bukowski RM, Lichtin AE (1992) Pseudo-gamma heavy chain (IgG4 lambda) deposition disease. Mod Pathol 5:185–190
31. Zollinger H-U, Mihatsch MJ (1978) Renal pathology in biopsy. Springer, Berlin Heidelberg New York