Renal Cystic Disease and Vascular Lesions of the Adrenal and Kidney

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Kelvin K.W. Liu and Michael W.Y. Leung

Abstract

Multicystic dysplastic kidney (MCDK) is the most common renal cystic disease in neonates. Autosomal recessive polycystic kidney disease (ARPKD) is an uncommon condition that can present in utero or early infantile period. Autosomal dominant polycystic kidney disease (ADPKD) and solitary renal cyst are rarely seen in newborns. Localized adrenal haemorrhage may occur in infants but massive haemorrhage is rare and is often confined to newborn. Renal vein thrombosis leading to haemorrhagic infarction has become much less common due to improved perinatal management. Renal artery thrombosis and stenosis are the main causes of renovascular hypertension in neonate

Keywords

Renal cystic disease • Adrenal lesions • Adrenal haemorrhage • Renal vein thrombosis • Renovascular hypertension • Management • Outcomes

66.1 Renal Cystic Disease

Multicystic dysplastic kidney (MCDK) is the most common renal cystic disease in neonates. Autosomal recessive polycystic kidney disease (ARPKD) is an uncommon condition that can present in utero or early infantile period. Autosomal dominant polycystic kidney disease (ADPKD) and solitary renal cyst are rarely seen in newborns.

66.1.1 Multicystic Dysplastic Kidney

Multicystic dysplastic kidney (MCDK) was first described by Schwarz in an infant with kidney replaced by a "bunch of grapes" [1] (Fig. 66.1). The incidence of MCDK is about 1 in 4000 live births with a male to female ratio of 3:2 [2, 3]. Left MCDK is slightly more common. Bilateral MCDK occurs in about 20% of cases leading to fetal loss, stillbirth

K.K.W. Liu, MBBCh, FRCS(Glas), FRACS, FRCS(Ed) (✉)
Division of Paediatric Surgery, Department of Surgery, United Christian Hospital, Hong Kong, China

M.W.Y. Leung, MBChB, FRCS(Ed, Paed), FCSHK
Division of Paediatric Surgery, Department of Surgery, Queen Elizabeth Hospital, Hong Kong, China
e-mail: liukwk@ha.org.hk

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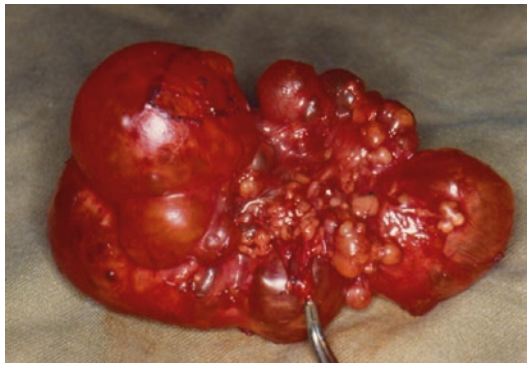

Fig. 66.1 Multicystic dysplastic kidney

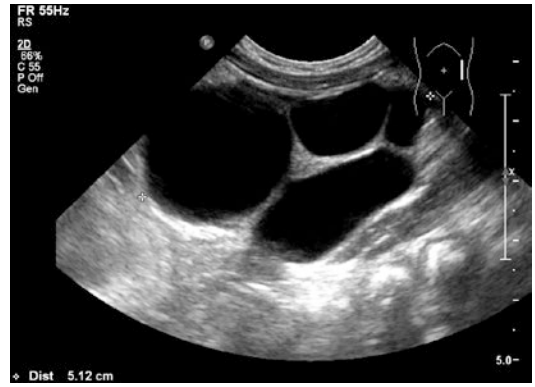

Fig. 66.2 Multicystic dysplastic kidney with almost complete replacement of renal parenchyma with cysts (Courtesy of Dr. Sunny Tse)

or early neonatal death as a result of oligohydramnios, pulmonary hypoplasia and renal failure [4].

66.1.1.1 Pathogenesis

MCDK is a variant of renal dysplasia. According to the ureteric bud theory of Mackie and Stephens, MCDK may be a consequence of abnormal induction of metanephric mesenchyme by the ureteric bud [5]. It is also hypothesized that MCDK can be caused by urinary tract obstruction during early gestational period [6].

Most MCDK occurs sporadically although familial occurrence has been reported. The *EYA1, SIX1 and PAX2* genes play important roles in ureteric bud development [7]. Mutations of these genes have been identified in Branchio-oto-renal syndrome and renal-coloboma syndrome associated with renal dysplasia [8–10]. In utero viral infections including cytomegalovirus may be associated with MCDK development [11].

66.1.1.2 Clinical Presentation and Diagnosis

Prenatal diagnosis by fetal ultrasound is the most common presentation of MCDK. Next to hydronephrosis, MCDK is the second most common aetiology of incidentally palpable abdominal mass in neonates. The two diagnoses can be differentiated by postnatal ultrasonography. The sonographic appearance of MCDK consists of haphazardly arranged multiple non-communicating cysts with variable size, separated by hyperechoic dysplastic stroma (Fig. 66.2). There is no pelvicaliceal structure. Atresia of the ureter can occur. When

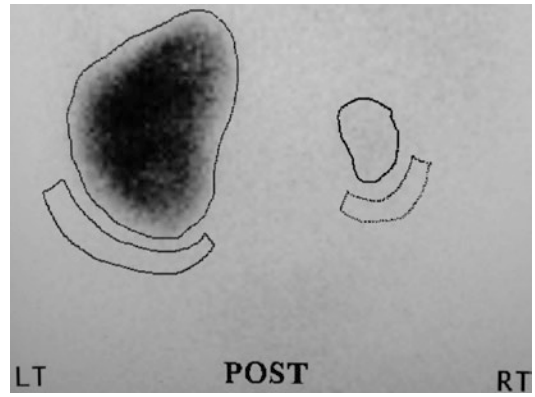

Fig. 66.3 Non functioning right kidney demonstrated on DMSA

an isotope mercaptoacetyltriglycine (MAG3) dynamic diuresis renography or dimercaptosuccinic acid (DMSA) scintigraphy is performed, MCDK is non-functional and can be distinguished from other causes of hydronephrotic kidney (Fig. 66.3).

The contralateral kidney can be abnormal. Vesicoureteric reflux (VUR) occurs in 4–43% of patients and pelviureteric junction (PUJ) obstruction can be found in up to 15% of cases [12–15]. As the contralateral kidney is the only functioning unit, its management is crucial. Micturition cystourethrography (MCUG) should be considered in MCDK patients [16]. Fortunately, majority of contralateral VUR is of low grade with tendency of spontaneous resolution [17].

66.1.1.3 Natural History

Less than 20% of prenatally diagnosed MCDK is clinically palpable [14]. Without antenatal detection, most patients with MCDK can be asymptomatic. Outcome of MCDK is variable. Spontaneous involution of MCDK can occur in up to 60% of patients, after a period of few months to 10 years [18, 19]. The involution velocity is higher in infancy period [20]. Small size of MCDK (<6 cm length) and presence of compensatory hypertrophy of contralateral kidney are positive predictors for complete involution [21, 22].

Urinary tract infection (UTI) is not common in MCDK as the associated ureteric atresia prevents ascending infection. The US National Multicystic Kidney Registry reported a UTI prevalence of 4.6% in 5 years follow-up [14].

The risk of developing hypertension is low in patients with MCDK. In a systemic review, Narchi reported six cases of hypertension developed in 1115 children [23]. Other series also suggested that the risk of hypertension development is lower than 3% on long term follow-up [14, 24]. Once hypertension has developed, conversion to normal blood pressure after nephrectomy can occur in only about one-third of cases [2, 25].

Concerning the risk of malignant change, there are case reports of Wilms tumour in patients with MCDK [26, 27]. The non-involuted intervening stroma of dysplastic kidney may be a focus for malignant degeneration. The higher prevalence of nodular renal blastema in these patients comparing with the general population may be related to the development of Wilms tumour [28]. However, in a systemic review of 26 studies for 1041 children with MCDK, none developed Wilms tumour [29]. Renal cell carcinoma and transitional cell carcinoma have been reported in adults with MCDK [30–32].

In conclusion, most children with unilateral MCDK do not have any long term consequences. However, the patients and parents should be informed of the implications of only one functioning kidney for lifetime.

66.1.1.4 Treatment

The role of nephrectomy in MCDK is controversial. In general, nephrectomy may need to be considered in cases of enlarged renal mass, persistent symptoms such as pain, development of complications including UTI or hypertension, suspicion of malignancy, concomitant surgery and poor compliance to long term follow-up. With recent advances in minimal invasive surgery, laparoscopic nephrectomy can be performed from either trans-peritoneal or retro-peritoneal route with evolution to single port operation [33, 34] (Fig. 66.4).

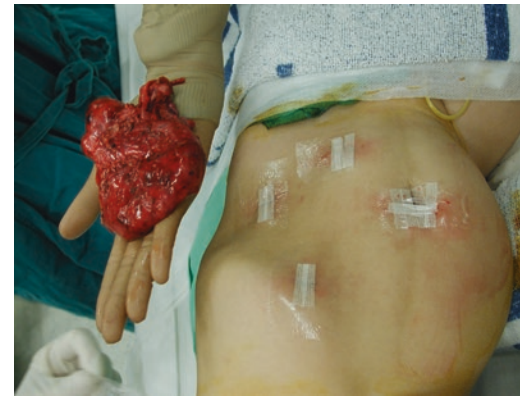

Fig. 66.4 Multicystic dysplastic kidney removed via trans-peritoneal laparoscopy

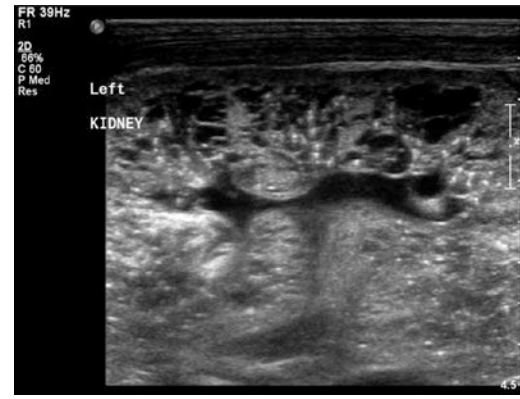

Fig. 66.5 Multiple cysts in autosomal recessive polycystic kidney (Courtesy of Dr. Sunny Tse)

66.1.2 Autosomal Recessive Polycystic Kidney Disease

Autosomal recessive polycystic kidney disease (ARPKD) occurs one in 10,000–40,000 live births [35]. It is previously also known as infantile polycystic kidney disease which is not an accurate ter-

minology as some patients can present at late childhood [36]. A single gene, *Polycystic Kidney and Hepatic Disease 1 (PKHD1)*, mutation on chromosome 6p was identified to account for the disease [37]. The disease affects both kidneys and liver invariably, characterized by the cystic changes of renal collecting tubules and congenital hepatic fibrosis (CHF) [38] (Fig. 66.5). Age of presentation and severity of renal symptoms depend on the number of abnormally dilated collecting ducts involved [39]. Antenatal diagnosis of bilateral renal masses, oligohydramnios and Potter sequence is common [40]. In neonates, patients will present with bilateral flank masses, impaired renal function and respiratory insufficiency. Neonatal death is usually caused by pulmonary complications. More than 70% of patients can survive beyond neonatal period, with progression to end stage renal disease and hypertension. The renal collecting tubules are affected, resulting in polyuria and polydipsia [41]. For long term survivors, hepatic manifestation as a result of CHF by abnormal ductal plate development will cause symptoms of hepatosplenomegaly, cholangitis, portal hypertension and oesophageal variceal bleeding [39].

Postnatal USG should be performed in neonates suspicious of ARPKD. Bilateral homogenously enlarged kidneys are seen with hyperechogenicity and poor corticomedullary differentiation. Renal cysts are small in neonates, different from those in MCDK and autosomal dominant polycystic kidney disease (ADPKD) [42]. Macrocysts are more common in older patients [43]. Hepatic parenchymal hyperechoic texture, cyst formation and occasionally intrahepatic ductal dilatation resembling Caroli's disease are found. If portal hypertension develops in juvenile period, splenomegaly and reverse hepatic venous flow can be demonstrated. If USG findings are equivocal, more sensitive imaging studies including computed tomography (CT) and magnetic resonance imaging (MRI), should be considered [44].

Treatment of ARPKD is mainly supportive. Recent advances in neonatal intensive care especially ventilation support decrease neonatal mortality from pulmonary hypoplasia. Patients will require treatment for chronic renal failure and hypertension. As the patients grow older, treatment for hepatic complications such as portal hypertension are necessary.

66.1.3 Autosomal Dominant Polycystic Kidney Disease

Autosomal dominant polycystic kidney disease (ADPKD) is the most common inherited human renal disease affecting one in 400–1000 people [45]. The age of onset is usually in third to fifth decades. Neonatal and early infantile presentations can occur that are not clinically distinguishable from ARPKD [46].

In 85–90% of patients with ADPKD, mutation of *PKD1* gene on chromosome 16p occurs [45]. Mutation of *PKD2* gene on chromosome 4q is found in rest of cases [47].

Extra-renal cysts in liver and pancreas, cardiac and cerebral manifestations are rare in neonates. USG may show enlarged hyperechoic kidneys, presence of macrocysts and increased corticomedullary differentiation [48]. Similar to ARPKD, management of early onset ADPKD is mainly supportive.

66.1.4 Solitary Renal Cysts

Contrary to adult population, solitary renal cyst is uncommon in children and extremely rare in neonates. It can occur sporadically or exist in patients with urinary tract obstruction such as posterior urethral valve [49]. USG is useful to differentiate it from other neonatal renal cystic diseases and hydronephrosis. Treatment of isolated solitary renal cyst is usually conservative. Image guided percutaneous aspiration of cysts had been reported in symptomatic children with loin pain [50].

66.2 Vascular Lesions of the Adrenal and Kidney

66.2.1 Adrenal Haemorrhage

The adrenal gland is vulnerable to haemorrhage due to its large size and high vascularity [51, 52].

Localized adrenal haemorrhage may occur in infants and children under stress [53, 54]. This condition is more frequently seen in term infants delivered vaginally [51, 55–57]. Massive adrenal haemorrhage, however, is much rarer and is often confined to newborns [58].

66.2.1.1 Aetiology

Birth trauma, prolonged labor, intrauterine infection, perinatal asphyxia or hypoxia, large birth weight, septicaemia, haemorrhagic disorder and hypothrombinemia are the most common predisposing causes of adrenal haemorrhage [52, 53, 56, 59]. In term infants, it is often related to large size following a difficult and traumatic delivery whereas in premature infants, perinatal hypoxia is often the predisposing cause. However it can also occur spontaneously [59]. Prenatal occurrence has also been documented [60].

66.2.1.2 Clinical Features

Clinical features vary depending on the amount of blood lost. The most common clinical presentations are persistent jaundice and flank mass [51, 52, 56, 57, 61]. However, adrenal haemorrhage may also present with scrotal haematoma, anaemia, adrenal insufficiency, shock [51, 55, 56, 59, 62], and as an incidental finding [63]. Macroscopic haematuria can occur if there is associated vascular lesion affecting the kidney. Breakdown of the red blood cells in haematoma causes jaundice. Adrenal insufficiency due to adrenal haemorrhage is rare [51, 52, 56, 57, 63] and is usually seen in premature infants [64]. As the adrenal gland has a considerable regenerative capacity, most adrenal haemorrhage is not associated with significant adrenal insufficiency. When adrenal insufficiency occurs, prematurity and severe underlying diseases such as sepsis, disseminated intravascular coagulation, perinatal hypoxia and intraventricular haemorrhage are also potential causes. Cytokine-related suppression of adrenocorticotropic hormone or cortisol synthesis, inadequate perfusion of the adrenal gland, a limited adrenocortical reserve or immaturity of the hypothalamic-pituitaryadrenal axis may also contribute to the development of adrenal insufficiency [65].

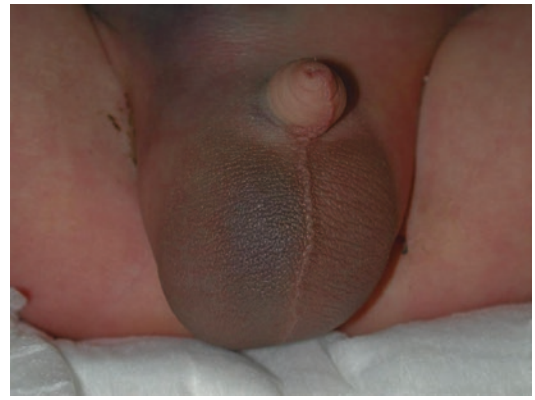

Fig. 66.6 Acute bluish discolouration and swelling of the right scrotum

Adrenal haemorrhage may present with swelling and bluish discoloration of the scrotum [51, 55, 56, 59, 62, 66] (Fig. 66.6). When adrenal haemorrhage occurs with rupture of the capsule, blood can easily reach the scrotum via the patent processus vaginalis or along the retroperitoneum [55, 62]. Swelling and discoloration of the scrotum in newborns may arise from other disorders, including torsion of the testis, epididymitis, scrotal or testicular edema, strangulated inguinal hernia and meconium peritonitis. Ultrasonography of the abdomen and scrotum should be performed in infants with scrotal swelling and ecchymosis to exclude adrenal haemorrhage [62]. If differential diagnosis between adrenal haemorrhage and torsion of the testis cannot be established, nuclear scanning or color Doppler analysis is required [62]. The right adrenal gland is the frequent (38–100%) site of adrenal haemorrhage [51–53, 55–57, 63]. This may be related to the direct drainage of the right adrenal vein into the inferior vena cava thus exposing the gland to the raised intravenous pressure that may occur during birth compression. Frequencies of 8–38% for bilateral adrenal haemorrhage have been reported [53, 56].

66.2.1.3 Diagnosis

Differential diagnosis of adrenal haemorrhage includes adrenal abscess, cystic neuroblastoma, cortical renal cyst, obstructed upper cortical renal cyst and an obstructed upper moiety of a duplicated kidney [67]. Measurement of urinary vanil-

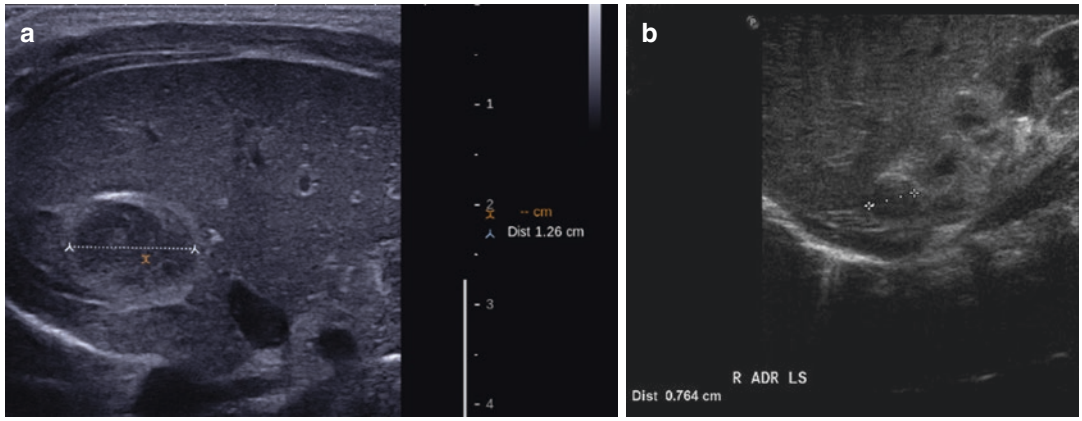

Fig. 66.7 Adrenal haemorrhage in a neonate (Courtesy of Professor Winnie Chu). Predominately cystic lesion with internal echoes over the right adrenal region. Interval reduction in size of the cystic lesion appearing more homogeneous and anechoic after 3 months

lylmandelic acid (VMA) levels assists in the differentiation of adrenal haemorrhage from neuroblastoma. The ultrasonographic appearance of adrenal haemorrhage depends on the age of haematoma, and this gradually resolves with time [61]. Diagnosis and follow-up of adrenal haemorrhage using ultrasonography is the most effective modality and avoids unnecessary laparotomy. Serial ultrasonography can demonstrate decrease in size and echogenity (Fig. 66.7), multiloculated cystic mass, calcifications and complete resolution of adrenal haemorrhage [55, 68]. Adrenal haemorrhage usually resolves between 3 weeks to 6 months [55–57, 59, 61]. For the case of neuroblastoma, the lesion remains solid in appearance and may enlarge over several weeks [51, 52]. In patients suggestive of adrenal insufficiency, cortisol and adrenocorticotropic hormone (ACTH) are measured and ACTH provocative test is performed. Rarely, adrenal haemorrhage may be associated with renal vein thrombosis. This may be due to the connection between the two venous systems or the same causative factor affecting both organs. It is therefore worthwhile to do imaging study to determine if the kidney has been affected by similar vascular lesion.

66.2.1.4 Treatment

Most cases of adrenal haemorrhage can be managed conservatively particularly in term infants. Occasionally blood transfusion for hypovolaemia, antibiotics for sepsis and hormonal treatment for bilateral involvement may be required. Most cases treated conservatively usually resolve with time. Occasionally the haematoma may calcify [69] and rarely becomes infected [70]. Surgery is seldom indicated except for dangerously high level of serum bilirubin or very extensive haemorrhage. Late sequelae of adrenal haemorrhage are uncommon.

66.2.2 Renal Vein Thrombosis

Renal vein thrombosis (RVT) leading to haemorrhagic infarction of the kidney was first described by Rayer [71] in 1837. It is predominantly a disease of the paediatric age group, primarily newborn infants [72, 73]. Between 60 and 75% of the cases are observed in the first month of life [72, 73] and about one third of all cases are diagnosed in the first week. Male infants are slightly more often affected than female. The number of surviving patients has increased, but at the same time, late complications are now being recognized with greater frequency [74–79].

66.2.2.1 Pathogenesis

It is now believed that the thrombus starts in an arcuate or interlobular vein, and it may spread in both directions to involve the renal cortex and to

occlude the main renal vein [80]. The thrombus may extend into the vena cava. However, spread to involve the contralateral kidney is unusual. Bilateral renal involvements are usually caused by thrombi arising from each kidney. Microthrombi found in small caliber veins of other organs in young infants support a generalized disease.

66.2.2.2 Aetiology

RVT occasionally occurs in previously well babies but dehydration has been implicated most commonly [73, 81, 82]. Infants of diabetic mothers seem to be susceptible [83, 84], and it has been observed as a complication of congenital heart disease, nephrotic syndrome, acute blood loss, sepsis, shock, or asphyxia at birth [85]. These associated factors together with the sluggish perfusion in the neonatal kidney and the relative polycythaemia render the neonate susceptible to RVT [73, 82].

66.2.2.3 Clinical Manifestations

RVT has a wide range of clinical manifestations. The complex of flank mass, gross haematuria, and thrombocytopenia should always alert the possibility of RVT. Swelling and cyanosis of the legs are indicative of thrombus within the inferior vena cava. Bilateral loin swellings, severe oliguria, anuria and azotaemia suggest bilateral renal involvement. In the first month of life, haematuria has been reported in 64% of cases and in older children in 49% [73]. Vomiting, diarrhea, pallor, cyanosis or shock, and the clinical signs of metabolic acidosis, occur in some infants. Prenatal RVT is a less common entity and has been found incidentally on prenatal imaging [86, 87].

Although the biochemical findings can vary greatly, decreased renal function is usually indicated by an increase in serum creatinine and blood urea nitrogen concentrations. At the same time, the serum bicarbonate level is decreased. The level of plasma potassium is significantly increased in about one third of the patients. The serum sodium level is variable, ranging from normal to high or low concentrations.

Renal venous thrombosis can sometimes be confused with hydronephrosis or a tumour within the kidney or adjacent tissues. Although rare in infants, a mesoblastic nephroma or hamartoma is an important differential diagnostic consideration. Furthermore, neuroblastoma and cystic disease of the kidneys are also palpated as abdominal masses in the newborn period.

66.2.2.4 Diagnosis

The clinical diagnosis of RVT can be supported by ultrasonographic and radiologic examinations. The plain film of the abdomen may show enlarged renal outlines. Ultrasonography is the technique most commonly used in the evaluation of neonates with suspected RVT [88]. The ultrasound appearances depend on the stage at which the examination is performed and the extent of the thrombus. Initially the thrombi in the peripheral small renal veins appear as highly echogenic streaks which only persist for a few days. In the first week the affected kidney swells and becomes echogenic with prominent echopoor medullary pyramids. Later, the swelling increases and the kidney becomes heterogenous with loss of corticomedullary differentiation. Grey scale ultrasound readily demonstrates thrombus within the renal vein and inferior vena cava. Colour Doppler may demonstrate absent intrarenal and renal venous flow in the early stages of RVT. Computed tomography (CT) can demonstrate both renal anatomy and function and is of help in the evaluation of a thrombotic process within the kidney [89]. Renal scintigraphy that measures glomerular filtration rate and renal plasma flow have been used in newborn infants to diagnose RVT and to estimate the renal function in the initial assessment and in monitoring upon the return of function during therapy. Tc-99 m mercaptoacetyltriglycine (MAG3) renal scintigraphy provides superior images because of its greater extraction and faster clearance and this is especially helpful in the neonates who inherently have immature renal function [90]. Similarly, renal nuclear magnetic resonance may be useful in evaluating the kidney, and particularly RVT. This technique demonstrates the anatomy, as well as the function, of the kidney and also any disease in the retroperitoneum. The intravenous pyelogram (IVP) in many cases shows no or minimal function on

one side while the other functions normally. Because of rather nonspecific and inconclusive findings, an IVP is of limited value in acute RVT. Renal angiography is an invasive study and is seldom required nowadays in the diagnosis of RVT.

66.2.2.5 Treatment

All children with RVT should be treated medically in the acute phase. Immediate treatment consists of correction of shock, metabolic acidosis, anaemia, sepsis, and cyanosis with or without hypoxia. Normal hydration must be achieved as soon as possible. If azotemia is present, fluid administration should be calculated to avoid overload. Anticoagulant therapy is still controversial [91, 92] Since extensive thrombosis is almost always present by the time of diagnosis, the usefulness of heparin is in doubt. Heparin probably should be used if RVT is diagnosed early [92] and in cases with evidence of intravascular coagulation or bilateral disease. If there is complete renal shutdown or the patient's condition deteriorates, early dialysis is beneficial. Haemodialysis is rarely used except in older patients with anuria. Surgery has only limited value in the treatment of RVT. Neither exploration of the kidney nor nephrectomy should be performed during the acute phase because the prognosis is generally favorable. Surgical intervention may be necessary in bilateral RVT, which usually also involves the inferior vena cava. Patients have recovered after thrombectomy [93], but even spontaneous recovery is known. Any other surgical procedure should be delayed for at least 4–6 months, when damage to the kidney can be defined more clearly after complete reevaluation and the appropriate procedure can be selected. Nephrectomy may be necessary for secondary complications such as hypertension, frequent infections of an atrophic kidney, or nephrotic syndrome.

66.2.2.6 Late Sequelae

Although the majority of neonates who receive supportive treatment can survive, structural or functional renal abnormalities are found in up to 90% of survivors [74–79]. Recanalization of occluded vessels or development of extensive collateral circulation may explain the functional recovery. There is a wide spectrum of complications including renal atrophy, renal tubular defects, growth retardation and hypertension. Hypertension seems to develop in only a few cases [74, 76]. It is usually accompanied by a high plasma renin level and is practically always relieved by nehrectomy. Recognition of these complications is important because early treatment can avoid many disturbing or debilitating diseases. The nephrotic syndrome has been diagnosed in older children with history of RVT. Present evidence favors the theory that the nephrotic syndrome is a precondition for the development of renal venous thrombosis rather than its late sequelae [94].

66.2.3 Renovascular Hypertension in Neonate

Hypertension in neonate may be seen in up to 2% of all infants cared for in neonatal intensive care unit [95]. It is increasingly recognized because of improved techniques of measurement and monitoring. Defining what is considered a normal blood pressure in newborn infants is a complex task. Studies in both term and preterm infants have demonstrated that blood pressure in neonates increases with both gestational and post-conceptual age, as well as with birth weight [95–97]. An infant's blood pressure is considered to be elevated if it falls above the upper limit of the 95% confidence interval for infants of similar gestational or post-conceptual age, size and gender.

The causes of hypertension in neonates are numerous, with the two largest categories being renovascular and other renal parenchymal diseases [98, 99]. Renal artery thrombosis accounts for 75% of cases of neonatal hypertension and renal artery stenosis for a further 18% [100]. Other renovascular problems may also lead to neonatal hypertension including renal vein thrombosis and diseases involving the renal artery either by direct involvement such as mid-aortic coarctation [101], idiopathic arterial calcification [102], congenital rubella infection [103], renal artery aneurysm [104], renal artery

embolism [105], or by compression of the renal artery such as hydronephrotic kidneys and other abdominal masses.

Although apparently spontaneous renal artery thrombosis has been reported [106], majority of cases occur as a consequence of umbilical artery catheterization used in the management of critically ill infants. A clear association between use of umbilical arterial catheters and development of arterial thrombi was first reported by Neal et al. [107] The association between umbilical arterial catheter-associated thrombi and the development of neonatal hypertension was confirmed by others [108, 109] though the rate of thrombus formation has been much lower than that reported by Neal. Thus, it is possible that the cause of hypertension in such cases is related to thrombus formation at the time of line placement, probably related to disruption of the vascular endothelium of the umbilical artery. Such thrombi may then embolize to the kidneys, causing areas of infarction and increased renin release. Isolated renal arterial stenosis is mainly caused by fibromuscular dysplasia. Although the main renal artery may appear fairly normal on angiography but there may be significant branch vessel disease that can cause severe hypertension [110].

66.2.3.1 Clinical Presentation and Diagnostic Approach

In many infants, hypertension will be discovered on routine monitoring of vital signs. However, other classic presentations of neonatal hypertension have been described. Congestive heart failure and cardiogenic shock represent life-threatening consequences of hypertension [111]. In the less acutely ill infant, feeding difficulties, unexplained tachypnea, apnea, lethargy, irritability, or seizures may constitute symptoms of unsuspected hypertension. In older infants unexplained irritability or failure to thrive may be the only manifestations of hypertension. In case of renal artery thrombosis, haematuria, azotaemia and proteinuria are the cardinal features. It is important that blood pressure is being measured accurately so that hypertension will be correctly identified. In most acutely ill neonates, blood pressure is usually monitored directly via an indwelling arterial catheter either in the radial or umbilical artery. Automated, oscillometric devices are less invasive and the more common alternative method of blood pressure measurement in most NICUs.

The correct cause of neonatal hypertension is usually suggested by careful history and physical examination. Relevant laboratory tests and diagnostic studies are then performed to confirm/exclude other non-renovascular causes. Determination of plasma renin activity is frequently performed in the assessment of neonates with hypertension. Although renal arterial stenosis and thromboembolic phenomenon are typically considered high renin forms of hypertension, a peripheral renin level may not be elevated in some infants despite the presence of significant underlying pathology. Selective renin level may yield more accurate information. Ultrasound and Doppler sonography should be performed and may detect potential correctable causes of hypertension such as renal vein thrombosis, renal artery thrombosis and renal artery stenosis. Renal scintigraphy may demonstrate abnormalities of renal perfusion. For infants with extremely severe blood pressure elevation, angiography may be necessary. A formal angiogram offers the most accurate method of diagnosing renal arterial stenosis, particularly given the high incidence of intrarenal branch vessel disease in children with fibromuscular dysplasia [110]. In extremely small infants, it may be appropriate to defer angiography, managing the hypertension medically until the baby is large enough for an angiogram to be performed safely. Because of the invasiveness of conventional renal angiography, magnetic resonance angiography has been reported by some to be of use in evaluation of renovascular cause of neonatal hypertension [111, 112]. Similarly, computed tomography angiography has been reported to be of help in the diagnosis of renovascular hypertension [113, 114] (Fig. 66.8).

66.2.3.2 Treatment

Immediate and urgent treatment consists of correction of hypertension. An antihypertensive agent should be chosen that is most appropriate for the specific clinical situation. For the majority of acutely ill infants, particularly those with severe hypertension, continuous intravenous

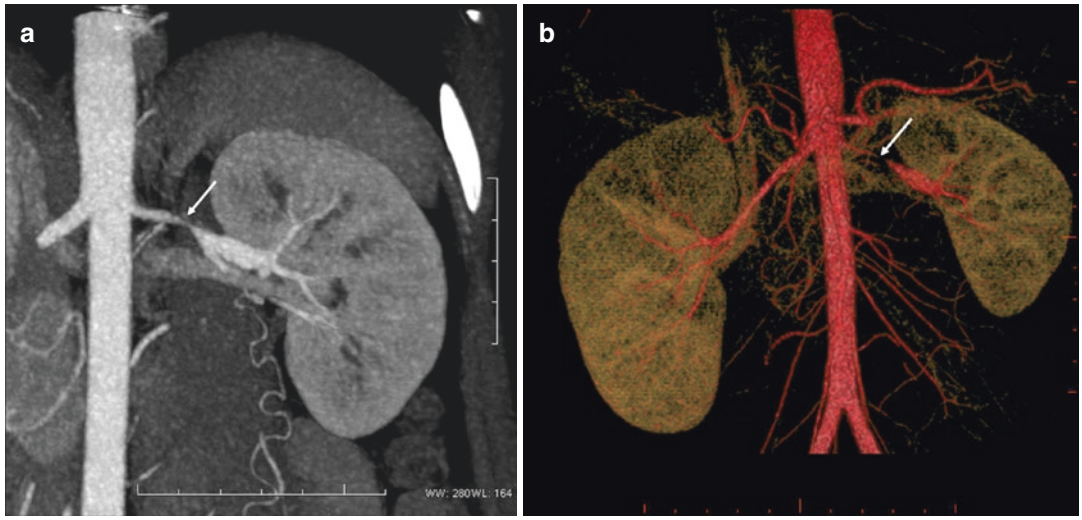

Fig. 66.8 Renovascular hypertension caused by renal artery stenosis (Courtesy of Professor Winnie Chu). (**a**) Coronal Reformat Contrast enhanced CT shows a focal stenosis (*arrow*) at the proximal left renal artery. (**b**) 3D volume rendering renal arteriogram shows again left renal artery stenosis (*arrow*) and relative smaller size of the left kidney when compared with the normal right side

infusion is the most appropriate approach. It is important to avoid too rapid a reduction in blood pressure [110] to avoid cerebral ischemia and hemorrhage, a problem that premature infants in particular are at increased risk. Surgery is indicated for treatment of neonatal hypertension due to renovascular cause in selected cases. For infants with renal arterial stenosis, it may be necessary to manage the infant medically until it has grown sufficiently to undergo definitive repair of the vascular abnormalities [115, 116]. Surgical reconstructive procedures include surgical dilatation, renal artery resection and reanastomosis, autologous or synthetic bypass grafts and autotransplantation. Good long term results have been reported but may sometimes result in primary or secondary nephrectomy [117, 118]. Percutaneous transluminal angioplasty for renal artery stenosis has been proven to be safe and effective in older children [119]. Generally good results outweigh the risks of recurrent stenosis and the rare but severe complications of dissection, rupture, bleeding, occlusion and aneurysm formation [119, 120]. Its successful use in neonate has also been reported [121]. For cases of severe hypertension with poor response to medical therapy, nephrectomy may have to be performed [122]. For cases of renal artery thrombosis that fail to respond to medical therapy, nephrectomy has to be performed as a lifesaving intervention [123, 124].

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