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Bilateral Renal Artery Stenosis Diagnosed with Vascular Ultrasound ina HypertensivePremature Neonate

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Abstract: *Neonatal hypertension (NHT) is rare,being most frequent in preterm neonates andrelated to diverse factors such as the overall mother's health, pregnancy occurrences, gestational age at birth and medication to promote foetal maturation. The etiologic causes of NHT are multiple, with renovascularhypertension being the most common. Besidesiatrogenic aetiology, where vascular endothelial injury in the aorta and/or renal artery occursfollowing umbilical artery catheterization, other aetiologies exist among which coarctation of the aorta andrenal artery in rare cases. This case report describes a premature new-born of 31 weeks' gestation with difficult to control hypertension and blood analysis alterations. Aduplex scan of the renal arteries was requested which revealed the existence of bilateral stenosis as a probable cause of high blood pressure valuesobserved and its inherent complications. This case demonstrates the importance of vascular ultrasonography in the evaluation and interpretation of the possible vascular causes of neonatal arterial hypertension.*

Keywords: *Doppler, hypertension, renovascular, neonate, ultrasound*

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I. Introduction

Neonatal hypertension is rare, with incidence between 0.2 and 3.0%, being observed more frequently in preterm neonates and related to factors such as gestational age, birth weight, history of maternal pathology and corticotherapy for foetal maturation[1]. It is defined by a systolic blood pressure in a neonate which is ≥95th percentile for age and sex on 3 separate occasions[2]. There are multiple etiologic causes of NHT, with renovascular hypertension being the most common where it may be secondary to arterial (aorta, renal) or venous thrombosis, fibromuscular dysplasia, idiopathic calcification, congenital rubella, mechanical compression or congenitalrenal artery stenosis[3]. Increased blood pressure caused by renovascular disease has been categorized as secondary hypertension as it results from renal hypoperfusion and subsequent ischemic changes to renal tissue[4].

The gold standard for a diagnosis ofrenal artery stenosis remains angiography, however it is notconsidered practical as a screening examination for most children and specially neonates due to its invasive nature and cost. Other known limitations are the radiation exposure and the need for these subjects to keep still during angiographic imaging[5].

Vascular ultrasound with the use of colour and pulse wave Doppler (duplex scan) has been used as a screening methodfor renovascular disease. This technique has the advantages of being a fast, safe and non-invasive method of assessing the renal vasculature and, if required,can be performed at bed side in a neonatal unit, with the results readily available for the medical team, enabling early detection of abnormalities and acute disease in the perinatal period[6]. Studies in adults have shown sensitivity of vascular ultrasound to be 75– 96% for the detection of renal artery stenosis, however there are no comparable large studies in children[7]. The typical duplex scan findings in arterial stenosis consist in raised blood flow velocity and spectral broadening with presence of turbulent flow passingthestenosed segment. As a result, other measurements are influenced by this phenomenon as the increase in acceleration time (AT) which indicates a slower systolic upstroke and damped peak following the stenosis. The resistance index (RI), a ratio of end diastolic velocity to peak systolic velocity, is also reduced when measured distally to a significant stenosis [8]. Measuring intrarenal flow and RI in the segmental or interlobar arteries is commonly used to assess renovascular resistance. The RI is normally <0.7 in adults, however this should be carefully interpreted in children as RI values differ according to their age,due to the physiological immaturity of neonatal kidneys. The RI can be as high as 0.9 in premature neonates, 0.6-0.8 in full term neonates and infants, only reachingsimilar adult values of 0.5-0.7 after 1 year old[5], [6].

II. Case Report

A pregnant woman with significant learning difficulties was admitted in an obstetric high dependent unit at 31 weeks+4 days gestation due to severe pre-eclamptic toxaemia and acute kidney injury. Suspicion of intrauterine hypoxia led to an emergency caesarean performed overnight of admission while not in labour, giving birth to a premature baby boy weighing 2060 grams. The baby was born in poor condition, resuscitated immediately with heart rate (HR) <60bpm, no spontaneous respiration, being floppy and pale. Initial chest compressions manoeuvres and mask inflation did not improve his condition and therefore oxygen, ventilation and intubation were administered, which resulted in improved HR >140bpm and O2 saturation of 98% at 9 minutes of life. Overall APGAR scores of 0 at 1 min, 6 at 5 minutes and 8 at 10 minutes.

While in neonatal intensive care unit,umbilical artery and vein catheters were inserted and initial clinical assessments revealed signs of respiratory distress of the new-born, haemodynamically significant *Patent Ductus Arteriosus*, persistent pulmonary hypertension, jaundice, hepatomegaly with birth liver injury probably secondary to chronic hypoxemia, intraventricular haemorrhage/parenchymal haemorrhage, anaemia of prematurity, other transient neonatal disorders of coagulation and neonatal hypertension.

In view of the raised blood pressure (BP) from day 1 of life, with mean BP: 60-80 mmHg and systolic BP: 100-120 mmHg, renal arteries ultrasound Doppler studies (duplex scan) were requested. This examination was performed using a Philips Affiniti Ultrasound System with C5-1 and C8-5 transducers which revealed presence of severe bilateral renal artery stenosis being likely congenital (Fig. 1 and 2) with peak systolic velocity (PSV) of 475cm/sec in the left and 392cm/sec in the right renal artery origin (Fig. 3 and 4). Distal segments of the renal arteries and the intrarenal waveforms were damped (Fig. 5), with increased AT and reduced RI, in keeping with the proximal renal arteries obstructions. The renal veins were patent and the visible umbilical catheter in the abdominal aorta appeared unrelated with the increased velocities detected at the renal arteries' origin, with no line thrombus detected. Flow waveforms in the abdominal aorta were normal.

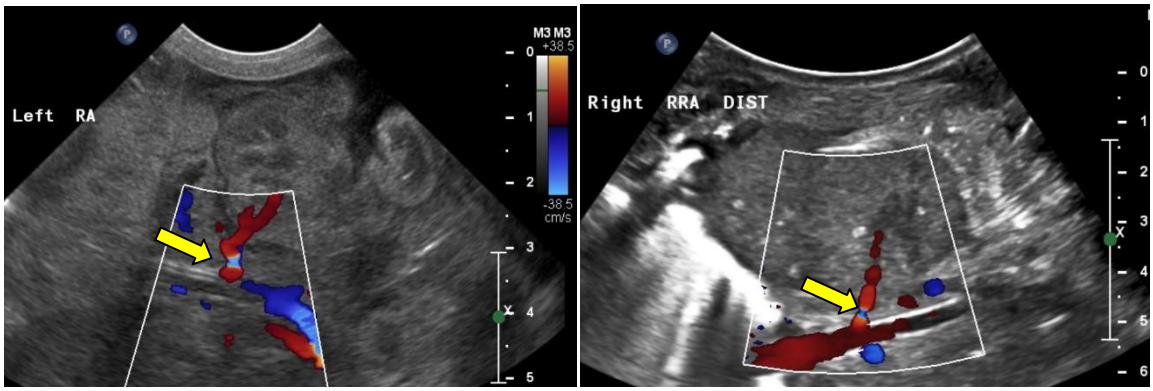

Figure 1 (left) and 2 (right): The yellow arrows indicate location of the left and right renal artery stenosis evidenced by the local aliasing colour Doppler, indicative of turbulent flow.

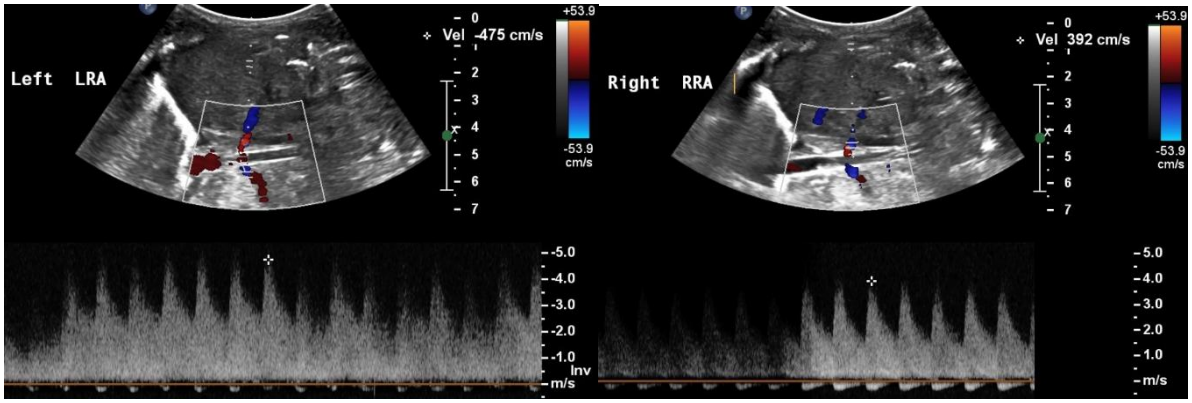

Figure 3 (left) and 4 (right): Spectral Doppler waveforms of the renal arteries stenosis with PSV of 475cm/sec in the left renal artery origin and 393cm/sec in the right renal artery origin.

These results were immediately communicated to the neonatal medical team and treatment of hypertension was then implemented with hydralazine infusion on day 6 as per renal team's advice. Despite this medication, creatinine and urea persisted abnormally raised on day 10 and baby showed signs of acute renal

failure with poor urine output and BP remained high. The renal team advised to stop hydralazine, start furosemide infusion, decrease IV fluids, correct acidosis with sodium bicarbonate and salbutamol to correct hyperkalaemia. Urine output improved with furosemide infusion.

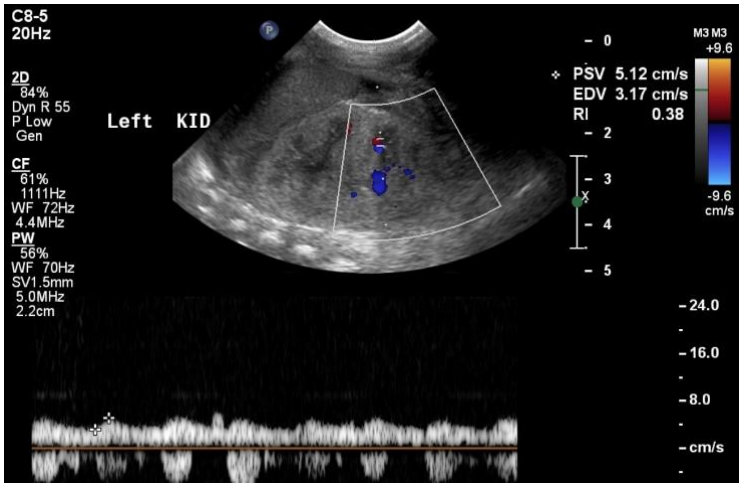

Figure 5: Intrarenal spectral Doppler waveforms in the left kidney demonstrating low PSV and damped "*tardus-parvus*" pattern as a result of the severe proximal renal artery stenosis.

A repeat duplex scan of the renal arteries and intrarenal flow was performed on the same day (10^{th}) in views of the worsening kidney function, which again revealed the severe stenosis bilaterally at the origin of the renal arteries with peak systolic velocities (PSV) >350cm/sec. The intrarenal flows were difficult to detect but, where seen, there was very low PSV with absent diastolic flow. This indicated a significant deterioration compared to the previous scan 4 days before where the intrarenal flow waveforms showed reasonable velocity forward flow throughout the cardiac cycle, which was not observed in this repeat scan.

With therapeutic changes, the baby then remained in polyuric phase of acute renal injury with improved urine output and fluid adjustments as required. As per suspicious of sepsis, decision was made to transfer the baby to another specialised neonatal unit at 33 weeks and 2 days with active problems at discharge of acute renal failure, liver failure and being ventilator dependent. Despite best medical treatment, the baby patient died on the following day with multiorgan failure.

III. Discussion

Renovascular hypertension is the most common cause of secondary hypertension.The most frequently reported causes of neonatal hypertension are stenosis of the proximal renal artery and renal artery thrombosis or embolization after umbilical arterial catheterisation which is an important risk factor, along with hypervolemia, central nervous system changes and bronchopulmonary dysplasia. The review of iatrogenic causes is therefore essential [9]. However, identifying a renovascular cause of hypertension in children and neonates with high blood pressure may prove to be difficult[8]. Renal vein thrombosis has also been implicated as a cause of NHT and has been described as a complication of maternal diabetes mellitus [10]. Reduced kidney perfusion causes renal release of renin, triggering the angiotensin system which results in hypertension. Renal artery stenosis is also increasingly recognised as an important cause of chronic renal insufficiency and end stage renal disease[11]. Unilateral renal artery stenosis causes ischaemic nephropathy on the affected side and uncontrolled hypertension leads to hypertensive nephrosclerosis on the nonaffected side, therefore both unilateral and bilateral renal artery stenosis may lead to progressive renal failure [12].

Duplex scan of the renal arteries enables visualization of blood flow, non-invasive evaluation of renal vascular resistance (using RI), and measurements of velocities in both renal and intrarenal arteries. These Doppler findings can be used in adults and children for diagnosis of renal artery stenosis, renal vein thrombosis, complications after renal biopsy, evaluation of blood flow in acute and chronic kidney inflammation and various parenchymal renal diseases[6].

Hypertension associated with renal artery stenosis is often severe and medical therapy may be ineffective or risky. Angioplasty or surgical revascularization procedure are recommended to help preserve renal function, prevent injury to other organs and reduce the need for life-long use of antihypertensive therapy. When only one kidney is affected, a nephrectomy is often considered and with severe bilateral or complex stenosis, kidney transplantation is also a treatment option [13].

This case report demonstrated the usefulness of the duplex scan of the renal arteries which was performed to a hypertensive premature neonate in its incubator. The findings of increased PSV and turbulence in

the proximal renal arteries, as well as the raised AT and a reduced RI in the distal segments of the renal arteries and in the interlobar arteries,often designated as a *tardus-parvus* waveform [14], led to the diagnosis of bilateral congenital renal artery stenosis. The fact of this examination being accomplished portably at the patient's bedside allowed an immediate feedback to the medical team which implemented the necessary therapeutic adjustments. Despite this, a repeat scan was performed due to the patient's worsening clinical condition and again demonstrated the renal arteries stenosis but also the fact that the intrarenal waveforms were deteriorating in keeping with progressive acute renal failure. It is unclear if the renovascular hypertension ultimately may have caused further complications in the baby's clinical condition as he was suffering from multiple organ failure and neurological changes were detected in a cranial ultrasound and brain MRI.

Hypertensive neonates benefit from an initial duplex scan screening to detects renal arterial or aortic thrombosis and alterations in the arterial waveform caused by intrinsic or extrinsic renal artery narrowing. A limitation of the duplex scan is the recognition of disease in accessory renal arteries or in small segmental intrarenal arteries which may frequently pass undetected[8]. The operator's experience is also an important factor to consider and more importantly so when renovascular paediatric scanning experience is even more scarce. It has been successfully used in children to diagnose renal artery stenosis in transplanted kidneys but the experience in adults for native kidneys is far more extensive with studies reporting a sensitivity of 60%–100% and a specificity of 70%–100%[15], with the differences reflecting variances in the frequency of accessory renal arteries, type of transducer, criteria used for diagnosing the stenosis or the importance of the ultrasound beam angle with the renal artery[16]. With regular clinical exposure to such cases, increased supervised training of accurate technique associated to the development of new technology and tools such as contrast-enhanced ultrasound [17], a better analysis of distal arteries is expectedand further improvementin accuracy of vascular ultrasound in the diagnosis of renal artery stenosis in children and neonates, avoiding other more invasive or risky procedures.

IV. Conclusion

With renal artery stenosis being an important cause of renovascular hypertension in term and premature neonates who present with high blood pressure in their early days of life, a duplex scan of the renal arteries has become a first screening method of diagnosing the presence of stenosis or other vascular disorders such as fibromuscular dysplasia. With the widespread availability of ultrasound in most clinical specialised facilities, the reliability of this examination is closely associated with the skill and experience of the operator. It is therefore of upmost importance that appropriate training is provided in this field to enable an early diagnosis of pathological findings as presented in this case of NHT.

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