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IN SONOGRAPHY RESEARCH

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contents

Paediatric neck ultrasonography: a pictorial essay

REFERENCE
Caprio MG, Di Serafino M, Pontillo G, Vezzali N, Rossi E, Esposito F, et al. *J Ultrasound.* 2019 Jun;22(2):215–26. doi: 10.1007/s40477-018-0317-2 Epub 5 Sept 2018.

REVIEWED BY
Ilona Lavender,
ASA SIG Paediatric

WHY THE REVIEW WAS PUBLISHED

Ultrasound of the paediatric neck is a common examination; however, not all sonographers are familiar with the range of pathologies that can be found in this region. This article describes the normal appearances seen in the paediatric neck and covers the most common pathologies that could be encountered.

WHAT THE ARTICLE IS LOOKING AT

The article commences by stating the importance of a high frequency transducer such as a 10–15 MHz and having a systematic approach when scanning. The systematic approach recommended when scanning the paediatric neck is:

1. perform cross-sectional scans of the entire gland, comparing the two lobes and measuring the anterior-posterior and transverse diameters
2. make longitudinal scans, measuring the longitudinal diameter
3. identify any focal lesions, measuring the largest one, where present
4. assess the presence of enlarged lymph nodes in the neck using transversal and lonigitudinal scans on the neck.

The normal anatomy of the neck is described, including the thymus, which is often seen in the paediatric patient – it is usually hypoechoic with thin hyperechoic straps and shouldn't be mistaken for pathology. The lymph node levels are clearly described (levels I–VII) and the normal measurements of the thyroid are given.

In most cases, to adequately assess the neck, the thyroid, salivary glands and lymph nodes should be examined.

This article describes a range of pathologies (with corresponding ultrasound images), which could be found when scanning the paediatric neck.

Thyroid diseases

Thyroid dysgenesis

This umbrella term includes a series of conditions such as aplasia, hypoplasia, hermiplasia and ectopia.

Thyroiditis

This is an inflammatory process resulting in the thyroid being heterogeneous, often with multiple hypoechoic regions. Colour Doppler is essential as there is hypervascularity in the acute phase and hypovascularity in the chronic stage.

Thyroid nodules

Nodules are rare with > 85% being benign. As FNA in the paediatric setting often requires sedation, care must be taken to describe the nodules. The article does not specify which nodules require an FNA.

Lymphadenopathies

The average patient will have 5–6 normal lymph nodes that appear oval, have a hyperechoic hilum and are less than 1 cm with the exception of the jugulodigastric nodes that can be up to 2 cm.

Cystic lesions

Thyroglossal duct cysts

This is the most frequent malformation in the neck in paediatric patients, mainly affecting females < 5 years of age. These are located in the midline and generally mobility is observed during swallowing.

Branchial cysts

These anomalies most commonly arise from the second brachial sulcus, and although congenital, appear in adolescence or puberty. They appear as cystic formations with clear margins, however, are at a high risk of infection.

Dermoid cysts

These are benign lesions often located along the medial line in the neck. While its margins are defined the texture can be homogeneous or heterogeneous depending on its content. Histology is required to confirm the diagnosis.

Haemangiomas and vascular malformations

Haemangiomas are benign lesions usually clinically diagnosed and appear within the first few weeks of life. A typical characteristic on ultrasound is its hypervascularity. Vascular malformations are present at birth and generally grow proportional to the child's development.

Fibromatosis colli

These are often referred to as sternocleidomastoid (SCM) tumours and are thought to be due to ischaemia of the muscle, often associated with forceps delivery. The SCM appears as a fusiform region with consequent shortening.

Pilomatrixoma

This is a benign tumour of the subcutaneous tissue appearing as an oval, heterogeneously hyperechoic lesion with a hypoechoic halo with calcifications.

RELEVANCE TO CLINICAL PRACTICE

Assessment of the paediatric neck is a common examination. This article is a valuable resource when pathology in the paediatric neck is observed, with good descriptors and corresponding ultrasound images. Furthermore, this article gives normal ranges for the thyroid gland. ■

> "The neck structures are located very superficially and are therefore easy to explore by ultrasound examination."

The efficiency of sonography in diagnosing volvulus in neonates with suspected intestinal malrotation

REFERENCE
Zhang W, Sun H, Luo F. Medicine (Baltimore). 2017 Oct;96(42):e8287. doi: 10.1097/MD.0000000000008287

REVIEWED BY
Emma Rawlings,
ASA SIG Paediatric

WHY THE STUDY WAS PERFORMED

Intestinal malrotation is one of the most common embryonic malformations of the gastrointestinal (GI) tract, with 80% of cases manifesting within the first month of life. Malrotation frequently leads to an upper GI tract obstruction resulting in symptoms of bilious vomiting and flat abdomen. These cases require emergent surgical intervention to prevent progression to midgut volvulus and intestinal necrosis. This study was conducted to evaluate the efficacy of sonography as a preferred imaging modality to the traditionally used fluoroscopic upper gastrointestinal tract contrast study.

HOW THE STUDY WAS PERFORMED

Eighty-three infants were recruited with clinically suspected malrotation and associated upper GI tract obstruction. Ultrasound was compared with upper GI tract contrast studies and the diagnosis confirmed via surgical exploration. Ultrasound was specifically evaluated for efficacy in diagnosing presence of malrotation, evidenced by inversion of the superior mesenteric artery (SMA) and vein (SMV) resulting in a left-sided SMV. Additionally, presence of a midgut volvulus was confirmed by the presence of the sonographic 'whirlpool sign', characterised by the clockwise winding of the small bowel around the superior mesenteric vessels and most effectively identified using colour Doppler. The degree of rotation of the small bowel was included in the sonographic evaluation.

WHAT THE STUDY FOUND

Ultrasound effectively diagnosed malrotation in 100% of positive cases (39/83) compared with 92.3% sensitivity in upper GI contrast studies. Of these patients, 21 demonstrated a volvulus upon surgical exploration. Ultrasound demonstrated the 'whirlpool sign' in 22 patients. This included two false-positives caused by other bowel pathologies, including jejunum diverticulum and intussusception with lead point, and one false-negative where there was no sonographically identifiable 'whirlpool' in the presence of a volvulus. This resulted in an overall accuracy of 92.3%. The study also showed that ultrasound accurately detected the degree of bowel rotation over 270° (270–1080°); however, was less effective at rotations less than 270°.

RELEVANCE TO CLINICAL PRACTICE

Ultrasound has shown to be more sensitive than upper GI tract contrast studies in the diagnosis of clinically indicated intestinal malrotation. This is sonographically indicated by an inverted SMA/SMV relationship. It is also a reliable indicator for presence of midgut volvulus, evidenced by a positive whirlpool sign, and effective at estimating degrees of bowel rotation above 270°. Additionally, ultrasound has the added advantage of diagnosing other causes of upper GI symptoms during the same examination, including annular pancreas, duodenal webs, duodenal atresia/stenosis, etc. It is, of course, the ideal modality for paediatric patients due to the absence of ionising radiation, and is portable, making its application in the neonatal and paediatric intensive care units superior. Given the need for surgical intervention, it is important for patients to receive the most timely and effective diagnosis. Sonography provides a superior means of diagnosis of malrotation when compared to the traditional upper GI contrast study and should therefore be encouraged as a first-line investigation in suspected cases. ■

> "... ultrasonography has potential benefits of portability, low levels of radiation exposure, and applicability to critically ill children who might be too sick to take a gastrointestinal contrast study."

Apical hypertrophic cardiomyopathy with left ventricular apical aneurysm: prevalence, cardiac magnetic resonance characteristics, and prognosis

REFERENCE
Yang K, Song Y-Y, Chen X-Y, Wang J-X, Li L, Yin G, et al. *Eur Heart J Cardiovasc Imaging.* 2020 Dec 1;21(12):1341–50.
doi: 10.1093/ehjci/jeaa246

REVIEWED BY
Richard Allwood
ASA SIG Cardiac

WHY THE STUDY WAS PERFORMED

The aim of this study was to investigate the prevalence, characteristic findings on cardiac magnetic resonance imaging (CMR), and prognosis of left ventricular apical aneurysms (LVAA) in patients with apical hypertrophic cardiomyopathy (ApHCM). It is suggested that hypertrophic cardiomyopathy with LVAA is associated with increased risk of adverse cardiovascular events.

HOW THE STUDY WAS PERFORMED

A retrospective study was performed with 1,332 consecutive ApHCM patients confirmed by CMR from January 2010 to June 2018.

A comparison was made between 31 patients identified with ApHCM and LVAAs (2.3%) and 31 age and gender matched ApHCM patients without LVAA. Patients with ApHCM with LVAAs were classified as pure or mixed based on the area of hypertrophy involved (Figure 1).

Clinical data was obtained including baseline characteristics from their electrocardiogram (ECG) and echocardiogram and information regarding their clinical symptoms, NYHA functional class and cardiac risk factors.

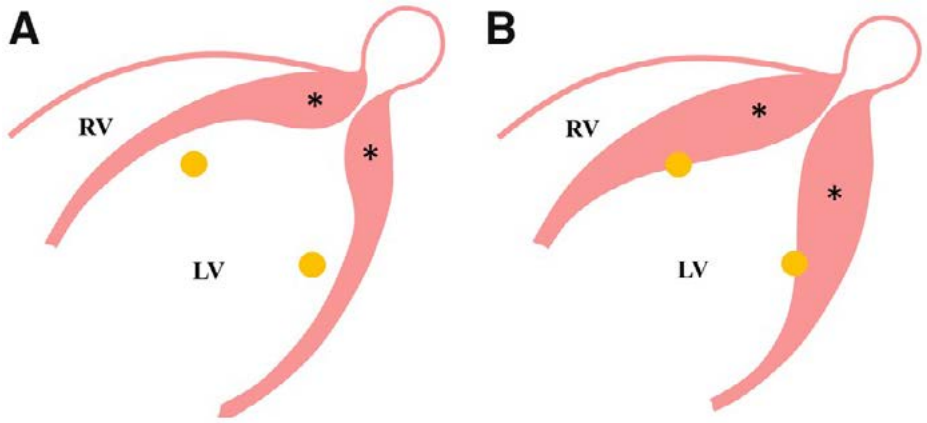

Fig 1. Illustration of two subtypes of ApHCM with LVAA – A (pure – myocardial hypertrophy limited to apical segments below the papillary muscle level) and B (mixed – predominantly apical hypertrophy along with thickening of non-apical LV region). Asterisks indicate hypertrophied myocardium; yellow dots indicate the papillary muscle level. LV: left ventricle, RV: right ventricle

WHAT THE STUDY FOUND

There was no statistical difference in ECG changes between the groups. Echocardiography missed the diagnosis of an LVAA in 64.5% of cases, with the majority small aneurysms < 20 mm.

ApHCM patients with LVAA had a significantly higher proportion of systolic mid-cavity obstruction and late gadolinium enhancement (LGE) present when compared to ApHCM without LVAA. These patients had a higher risk of adverse cardiovascular events, and those with extensive LGE had a worse prognosis compared with patients with LGE < 15%.

RELEVANCE TO CLINICAL PRACTICE

ApHCM with LVAA is a rare condition in clinical practice, which is often missed by echocardiography and can be reliably detected with CMR. This may be due to the aneurysm size, technically difficult imaging or inexperienced sonographers.

It has been demonstrated that the use of contrast-enhanced ultrasound (CEU) can improve the identification of LVAA in ApHCM patients on echocardiography. CEU can improve delineation and opacification of the LV cavity. As a sonographer, it is important to have an understanding of the appropriate use of CEU, and the characteristic findings of ApHCM.

In this study, ApHCM with LVAA group did have a higher prevalence of systolic mid-cavity obstruction, which may play an important role in the development of apical aneurysm formation. It is important to understand this association as a sonographer may consider the use of CEU to exclude a small LVAA in the presence of mid-cavity obstruction.

An ECG can also provide a clue to the presence of ApHCM and should be performed or reviewed if you suspect ApHCM. A high prevalence of patients with hypertrophic cardiomyopathy present with voltage criteria for left ventricular hypertrophy (LVH) and pathological T-wave inversion with a greater extent involving the lateral leads. These findings should prompt a sonographer to consider the use of CEU, to better visualise the LV apex.

Other characteristic findings include LVH predominately in the LV apex, with wall thickness ≥ 15 mm, and a loss of usual apical wall thickness tapering, with a spade-like configuration of the LV cavity at end-diastole.

A negative echocardiogram result does not exclude the possibility of LVAA in those with ApHCM, and further investigations, such as CMR and CEU, are essential for the diagnosis of this condition. ■

1. Yang K, Song Y-Y, Chen X-Y, Wang J-X, Li L, Yin G, Zheng Y-C, Wei M-D, Lu M-J, Zhao S-H . Apical hypertrophic cardiomyopathy with left ventricular apical aneurysm: prevalence, cardiac magnetic resonance characteristics, and prognosis. *European Heart Journal – Cardiovascular Imaging*. 2020 Dec;21(12):1341–50. https://doi.org/10.1093/ehjci/jeaa246
2. Hughes RK, Knott KD, Malcolmson J, Augusto JB, Mohiddin SA, Kellman P, Moon JC, Captur G. Apical Hypertrophic Cardiomyopathy: The Variant Less Known. *J Am Heart Assoc*. 2020 Mar 3;9(5):e015294. https://doi.org/10.1161/JAHA.119.015294
3. D'Ascenzi F, Anselmi F, Adami PE, et al. Interpretation of T-wave inversion in physiological and pathological conditions: Current state and future perspectives. *Clin Cardiol*. 2020;43:827–33. https://doi.org/10.1002/clc.23365

"Compared with ApHCM patients without LVAA, ApHCM patients with LVAA had a significantly higher proportion of systolic mid-cavity obstruction and LGE presence (both P < 0.05)."

Echocardiographic evaluation of patients undergoing cancer therapy

REFERENCE
Frey MK, Bergler-Klein *J. European Heart Journal – Cardiovascular Imaging*. 2021 Jan;22(4):375–82. doi: https://doi.org/10.1093/ehjci/jeaa341

REVIEWED BY
Samantha Burgoyne
ASA SIG Cardiac

WHY THE PAPER WAS WRITTEN

Short- and long-term side effects of cancer therapy are gaining increasing importance, particularly given the advancements in oncology treatment. Echocardiography is currently the best established and the most clinically easily feasible tool to detect cardiotoxicity in these patients. This review focuses on the most commonly used oncology therapies and provides a practical approach to guide clinicians.

HOW THE PAPER WAS WRITTEN

A comprehensive literature review was performed by Frey and Bergler-Klein.

WHAT THE PAPER COVERS

The paper reviews the different types of chemotherapy that are known to have cardiotoxic effects (both acutely, early or late) and the use of echocardiography in determining these effects. A range of oncology therapies are listed, with specific details of incidence of cardiotoxic effects, how cardiotoxicity may manifest (e.g. myo- and pericarditis) and whether these manifestations are reversible or not. Included are anthracyclines, HER2-targeted treatment, vascular endothelial growth factor inhibitor and Bcr-Abl tyrosine kinase inhibitor treatment, proteasome inhibitors, and immune checkpoint inhibitors. The echocardiographic assessment parameters reviewed included left ventricular systolic function, left ventricular volumes, left ventricular diastolic function, right ventricular function, left atrial size and function. The paper also covers how often echocardiography should be performed depending on the cancer treatment. For instance, guidelines for a patient treated with anthracyclines include an echocardiogram at baseline, after completing cumulative doses of 240 mg/m^2, every 2 cycles in medium to high risk, 6–12 months after final cycle and a reassessment after 5 years (depending on overall risk).

RELEVANCE TO CLINICAL PRACTICE

Echocardiography is useful before, during and after cancer treatment. Performing an echocardiogram before treatment enables baseline cardiovascular risk stratification of patients. Table 1 below displays how patients are categorised as low, medium or high risk depending on therapy – and patient-related factors. During cancer treatment, echocardiography can detect early signs of cardiotoxicity. Long-term effects can be assessed with echocardiography as well, long after treatment has ceased.

The paper discusses limitations of each parameter. For instance, left ventricular ejection fraction may not be accurate due to inter- and intra-observer variability, test–retest variability, breast surgery, chest radiation or cachexia. Some practical solutions include repeat echocardiography before any definite decision on change of cancer treatments, use of 3D and use of contrast. It was unclear whether LV diastolic function was useful as a marker for cardiotoxicity; however, overall, the paper recommended recording baseline diastolic function for general cardiac risk assessment and follow-up during cancer treatment.

Echocardiographic evaluation of patients undergoing cancer therapy *cont.*

Table 1: Assessment of baseline risk of cardiotoxicity

THERAPY-RELATED FACTORS	PATIENT-RELATED FACTORS
Low risk Lower dose AC Transtuzumab alone	Age between 18 and 50 years
Medium risk Modest dose AC AC followed by transtuzumab VEGF TKIs Bcr-Abl TKIs (2nd and 3rd generation) Proteasome inhibitors ICIs	Age 50–64 years 1–2 CV risk factors (hypertension, dyslipidaemia, obesity, insulin resistance and smoking) Borderline EF (50–54%)
High risk Simultaneous AC and transtuzumab High-dose AC AC and chest radiation High-dose chest radiation VEGF TKIs after AC therapy	Age 65 years More than 2 CV risk factors Underlying CV disease: CAD, PAD, CMP, and VHD Heart failure (EF under 50%) Prior cancer therapy

Adopted from Refs.1,4. AC, anthracyclines; CAD, coronary artery disease; CMP, cardiomyopathy; CV, cardiovascular; ICIs, immune checkpoint inhibitors; PAD, peripheral artery disease; TKIs, tyrosine kinase inhibitors; VEGF, vascular endothelial growth factor; VHD, valvular heart disease.

Table 2: Relevant parameters for cardio-oncology echocardiography

PARAMETERS	SIGNS OF CARDIOTOXICITY	COMMENTS
LV systolic function		
LVEF (2D biplane Simpson, 3D automated)	Decline by 10% points below 50% (53%)	Inter- and intraobserver variability can be reduced with 3D EF
GLS	Relative reduction of > 15% (from baseline to below LLN)	Early marker of cardiotoxicity Average from 3 apical views should be used
LV volumes	Increase of 15 ml for LV ESV or 30235 mL or LV EDV	Consider extensive and varying loading conditions during chemotherapy, diarrhoea and emesis
LV diastolic function	Minor prognostic value debated	Baseline diastolic function useful for general risk assessment
LA size	Baseline LA dilatation and LA GLS may be predictive	
RV systolic function, pulmonary artery pressure	Prognostic role in heart failure	Assess TAPSE, RV free wall strain and TR velocity for PAPs at baseline & during chemotherapy

It is well-known that global longitudinal strain (GLS) is important to include when performing an assessment of cardiotoxicity; however, as displayed in Table 2 above, there are other parameters that can flag possible problems. A decline in LVEF and/or increase in LV ESV or EDV can be indicators of cardiotoxicity. Other echocardiography parameters are being developed and researched in this advancing field of oncology therapies. These include new strain imaging methods (i.e. myocardial work index), echocardiography and biomarker algorithms, and 3D technology. ■

> "...echocardiography presents a major cornerstone in cardio-oncology surveillance."

Imaging and pathological features of idiopathic portal hypertension and differential diagnosis from liver cirrhosis

REFERENCE
Zhao Z-L, Wei Y, Wang TL, Peng LL, Li Y, Yu MA. *Sci Rep.* 2020:10(1):2473 https://www.ncbi.nlm.nih.gov/pubmed/32051517

REVIEWED BY
Robyn Boman,
ASA SIG General

WHY THE STUDY WAS PERFORMED

This article looked at idiopathic portal hypertension (IPH), which is a relatively rare disorder characterised by portal hypertension without cirrhosis, from a retrospective study. Imaging of IPH may demonstrate a similar appearance in imaging to cirrhosis, as it can lead to hepatic failure, splenomegaly, variceal bleeding, and ascites. The causes for idiopathic portal hypertension include various types of drugs, non-infectious hepatitis, autoimmune diseases, such as Hashimoto's thyroiditis and rheumatoid arthritis.

HOW THE STUDY WAS PERFORMED

The article discusses the incidence of splenomegaly, portal-systemic collaterals, nodular surface, hepatic nodules, segment size, portal vein enlargement, portal vein stenosis and hepatic artery enlargement in IPH. This is compared to a normal population with an age range of 39 +/- 20 years.

WHAT THE STUDY FOUND

There is discussion on pathological changes in IPH and liver cirrhosis and the differences between IPH and liver cirrhosis based on imaging and pathology. In Table 3, the diameter of the portal vein wall thickness, and the ratio of these two parameters are compared for three (3) points in the portal venous system within the liver. Spleen/liver stiffness ratio has also been discussed and this may be effective in distinguishing between IPH and liver cirrhosis. Images of the liver from ultrasound, computed tomography, magnetic resonance imaging and pathology were compared retrospectively over a four-year period. This article provides discussion on the opportunity for comparison of these two differentials.

RELEVANCE TO CLINICAL PRACTICE

As IPH can mimic liver cirrhosis with imaging currently unable to differentiate efficiently, a robust history from the referrer and the patient may assist in obtaining a differential diagnosis to include IPH in the differentials for the ultrasound findings. Reviewing the portal vein wall thickness may be a guide for this differential and in turn may assist the patient in a more appropriate treatment pathway. ■

> "Idiopathic portal hypertension (IPH) mimics liver cirrhosis in many aspects, and no efficient imaging method to differentiate the two diseases has been reported to date."

Imaging in scrotal trauma: a European Society of Urogenital Radiology Scrotal and Penile Imaging Working Group (ESUR-SPIWG) position statement

Imaging plays a crucial role in the evaluation of scrotal trauma, with B-mode and Doppler ultrasound being the primary techniques. The selective use of contrast-enhanced ultrasound (CEUS) and shear wave elastography (SWE) may be indicated. However, the diagnostic performance of ultrasound in imaging scrotal trauma has not been fully established. This article is a summation of an expert task force – the ESUR SPIWG – which reviewed the current literature and consolidated their imaging and examination expertise for various entities in scrotal trauma. The aim of the paper was to guide the role of imaging in a multiparametric ultrasound (MPUS) approach.

The paper is a composition of twenty position statements addressing every stage of scrotal trauma – from clinical assessment through to diagnosis and management. It emphasises that the recommended clinical baseline is that the examining sonographer is provided with information regarding the mechanism and type of scrotal trauma. This leads in to eighteen imaging subsets aimed at diagnosis, management and follow-up of different scrotal trauma entities. The guidelines provide detailed ultrasound criteria to differentiate between surgical and non-operative management. The use of CEUS is recommended to assess flow when colour Doppler is not diagnostic and SWE is advised in trauma to differentiate between hematomas and tumours. The position statements provide advice on the role of CT and MRI, especially in the setting of polytrauma. Each position statement is supported by literature and evidence-based text.

The paper is recommended for a broad range of sonographers irrespective of experience level. It serves as a current consensus document for sonographers involved in scanning the scrotum and subsequently directing patient management. It serves as a good baseline document to direct department protocols for application across private and public centres.

REFERENCE
Ramanathan S, Bertolotto M, Freeman S, Belfield J, Derchi L, Huang D, Lotti F, et al. *European Radiology*. (2021)31:4918–28. https://link.springer.com/article/10.1007/s00330-020-07631-w

REVIEWED BY
Marilyn Zelesco
ASA SIG General

NOT OPEN ACCESS

"Ten per cent of intratesticular tumours are detected incidentally in patients presenting with a history of scrotal trauma."

Interpretation of peripheral arterial and venous Doppler waveforms: A consensus statement from the Society for Vascular Medicine and Society for Vascular Ultrasound

REFERENCE
Kim EH, Sharma AM, Scissons R, Eberhardt RT, Hughes JP, Dawson D, et al. *Vasc Med*. 2020 Oct;25(5):484–506.
https://journals.sagepub.com/doi/full/10.1177/1358863X20937665
REVIEWED BY
Daniel Rae
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WHY IT WAS PERFORMED

With peripheral arterial disease affecting around 200 million worldwide, and venous thromboembolic disease accounting for > 600,000 hospital admissions yearly in the United States, establishment and adoption of nomenclature for spectral Doppler waveform characterisation is essential for communication of disease presence and severity.

'The purpose of this consensus statement is to:

- clarify and standardise key definitions and descriptors that are inherent to the analysis of arterial and venous Doppler waveforms
- review Doppler waveform alterations with physiologic changes and disease states
- provide Doppler transducer optimisation techniques to enhance the quality and presentation of Doppler spectral waveform and colour Doppler data
- provide guidance for applying waveform Descriptors and Modifiers—Sonographer's Report and Physician's Final Interpretation.'

HOW IT WAS PERFORMED

An initial clinical impact survey was performed where around 2000 ultrasound professionals commented on the non-standardised waveform nomenclature. 'One-fifth of the respondents reported one or more occurrences of repeat arterial Doppler examinations because of lack of understanding of the terminology used to describe Doppler waveforms.'

A writing committee was established, comprised of sonographers and physicians who are members of the Society for Vascular Medicine and Society for Vascular Ultrasound. The committee was tasked to standardise Doppler waveform nomenclature so inappropriate testing can be avoided by way of accurate and consistent communication of vascular diagnostic test results.

WHAT WAS DISCUSSED

Table 1 lays out the key consensus points of the study. The consensus paper covers the fundamentals of a large range of arterial and venous waveform nomenclature and descriptors within a normal physiological state.

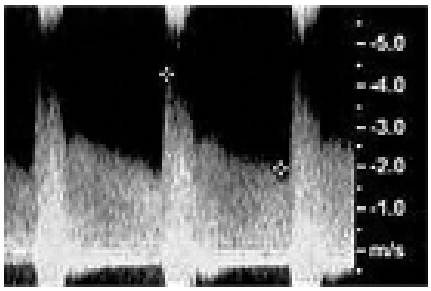
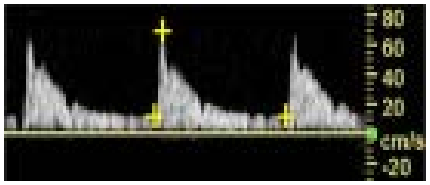
It goes on to explore common vascular pathologies which cause changes in the waveform and provides descriptions of these changes. An example has been taken in Table 2 that demonstrates normal and abnormal renal artery waveforms.

Interpretation of peripheral arterial and venous Doppler waveforms: A consensus statement from the Society for Vascular Medicine and Society for Vascular Ultrasound *cont.*

Table 1. Key consensus points

▪ The reference baseline for spectral Doppler waveforms will refer to the zero-flow baseline. ▪ All arterial and venous waveforms will be described using key descriptors and modifiers as listed below. ▪ Optimisation techniques should be used to provide quality Doppler waveforms for accurate interpretation. ▪ Waveform descriptors and modifiers, velocity measurements, and image descriptors are test findings, not interpretations. To be clinically useful to the ordering provider, test data, including waveform findings, should be used by the interpreting physician along with exam-specific, validated diagnostic criteria to determine the final interpretation or conclusion of the vascular study.		
Arterial	Key major descriptors	▪ Flow direction (antegrade, retrograde, bidirectional, absent)
		▪ Phasicity (multiphasic, monophasic)
		▪ Resistance (high, intermediate, low)
	Additional modifier terms may also be utilised	▪ Upstroke (rapid, prolonged)
		▪ Sharp peak
		▪ Spectral broadening
		▪ Staccato
		▪ Dampened
		▪ Flow reversal
Venous	Key major descriptors	▪ Flow direction (antegrade, retrograde, absent)
		▪ Flow pattern (respirophasic, decreased, pulsatile, continuous, regurgitant
		▪ Spontaneity (spontaneous, nonspontaneous)
	Additional modifier terms may also be utilised	▪ Augmentation (normal, reduced, absent)
		▪ Reflux
		▪ Fistula flow

Table 2. Normal and abnormal renal artery waveforms

Physiologic state and explanation	Waveform figure
Normal renal artery Flow in the normal main and/or accessory renal artery is antegrade, low resistive, and monophasic.	
Pathophysiologic state and explanation	**Waveform figure**
> 60% renal stenosis Waveform remains antegrade, low resistive, and monophasic in the absence of distal renal artery stenosis or intrinsic renal parenchymal disease. The velocities shown here are > 180 cm/sec, a commonly used criterion for renal artery stenosis.[49]	
Renal downstream from flow-reducing stenosis Antegrade, prolonged upstroke, low resistive, and monophasic with low PSV.	
Intrinsic renal parenchymal dysfunction (Medical renal disease) Decreasing diastolic flow, antegrade, high resistive, and either monophasic or multiphasic.	

Interpretation of peripheral arterial and venous Doppler waveforms: A consensus statement from the Society for Vascular Medicine and Society for Vascular Ultrasound *cont.*

Further to this, the paper discusses Doppler waveform optimisation, which includes Doppler parameters and artifacts.

HOW THIS WILL BENEFIT SONOGRAPHERS

Improved understanding of waveform fundamentals will enable sonographers to identify changes occurring from altered physiological and disease states. This will in turn improve effective communication of these changes in a consistent manner, so confusion and delayed diagnosis is avoided. ■

> "Sonographers should be able to describe Doppler waveforms, be able to identify the changes which occur with physiologic and disease states, and effectively communicate these waveform characteristics to interpreting physicians."

Optimisation of duplex velocity criteria for diagnosis of internal carotid artery (ICA) stenosis: A report of the Intersocietal Accreditation Commission (IAC) Vascular Testing Division Carotid Diagnostic Criteria Committee

REFERENCE
Gornik H, Rundek T, Gardener H, Benenati F, Nirvikar D, Hamburg N, et al. *Vasc Med*. 2021 May 19. https://journals.sagepub.com/doi/pdf/10.1177/1358863X211011253

REVIEWED BY
Matt Adams
ASA SIG Vascular

WHY THE STUDY WAS PERFORMED

There has been ongoing effort over the past 40 years to refine and standardise duplex ICA stenosis criteria. The IAC for vascular testing have been key commentators on the lack of standardisation of ICA stenosis grading criteria in recent times. In 2012, the IAC conducted a survey that revealed that more than two-thirds of their own staff believed that there should only be one set of diagnostic criteria. As a result of this, the Carotid Diagnostic Criteria Committee was commissioned to perform a comprehensive research study.

HOW THE STUDY WAS PERFORMED

This was a multicentre, retrospective, correlative imaging study comparing catheter angiography with duplex ultrasound in the assessment of ICA stenosis. All participating sites were IAC accredited and limited demographic and clinical information was provided for each case. Inclusion criteria were that each case had full bilateral carotid artery duplex ultrasound assessment (inclusive of at least proximal CCA, distal CCA, proximal ICA and distal ICA velocity measurements to IAC standard) accompanied by bilateral catheter angiography performed within 3 months of the ultrasound. Cases with previous carotid endarterectomy, stenting, tandem lesions or non-atherosclerotic disease were excluded. Ultrasound images were assessed for adequacy by a registered vascular technologist; images were then interpreted by two physician reviewers blinded to the angiography results based on standardised definitions of plaque, waveforms and manifestations of turbulence. Reviewers provided a % ICA stenosis using SRU criteria that had to be agreed on by a fellow reviewer. Angiography images were also assessed by at least two reviewers blinded to the duplex images. Multiple views of the ICA were used for each case and % stenosis was measured using the North American Symptomatic Carotid Endarterectomy Trial criteria.

WHAT THE STUDY FOUND

Only moderate agreement was found between catheter angiography and duplex ultrasound for categorisation of ICA stenosis. Of 299 ICA sides, from 167 patients, there were fewer 50–69% (18.7% v 29.1%) and ≥ 70% (11.0% v 24.4%) stenoses detected by angiography than ultrasound. Duplex agreed with angiography categorisation of < 50% ICA stenosis in 64.2% of cases. There was agreement in 42.9% of cases by ultrasound in cases with disease graded at 50–69% by angiography; however, in 53.6% of these cases there was disagreement with ultrasound, upgrading the severity of the lesion to ≥ 70%. On the other hand, 69.0% of stenoses graded as 50–69% by ultrasound were in the < 50% category according to angiography. Agreement between duplex and angiography was excellent (90.9%) for ≥ 70% lesions detected by angiography; however, over half of ≥ 70% stenoses graded by ultrasound were in less severe groups (41.1% in 50–69% and 16.4% in < 50%) when evaluated by angiography. In regard to differentiating ≥ 70% from < 70% stenoses

Optimisation of duplex velocity criteria for diagnosis of internal carotid artery (ICA) stenosis: A report of the Intersocietal Accreditation Commission (IAC) Vascular Testing Division Carotid Diagnostic Criteria Committee *cont.*

using peak systolic velocity (PSV), the SRU threshold of ≥ 230 cm/s had adequate sensitivity but inadequate specificity and that if solely using a PSV parameter, then performance was optimised using a figure of ≥ 260 cm/s. Interestingly, an ICA/CCA PSV ratio of ≥ 3.3 had better sensitivity (93.9%) for predicting ≥ 70% v < 70% stenosis than the widely accepted ratio of 4 (sensitivity 81.8%).

RELEVANCE TO CLINICAL PRACTICE

This study highlights concerns surrounding the efficacy of duplex ICA stenosis criteria in current clinical practice. Fortunately, the trends in data from this review demonstrate that ultrasound is more likely to overestimate severity of ICA disease compared to gold standard. While this is better than severe disease going undiagnosed, this does represent a potential source of patient anxiety and inefficient use of resources. Carotid duplex criteria are in desperate need of updating via multicentre and multidisciplinary review, but should the focus be on velocities and ratios? Of course, these parameters are analysed in conjunction with demographic and clinical factors of the patient, but highly variable interpretation of ultrasound results remain. Maybe the focus should now switch to trying to create feasibility to routinely conduct evolving methods such as contrast-enhanced ultrasound or microvascular imaging to detect vulnerable carotid plaques or employ tomographic techniques that have been shown to measure plaque volume with comparable accuracy to angiography. This report by the IAC does show how carotid duplex criteria can be optimised in its use as a complementary modality, but we have the skills and technological capabilities within the field of sonography to make it a gold standard in the future. ■

> "In a real-world correlative imaging study performed with case studies obtained from IAC accredited vascular laboratories, interpretation of carotid duplex ultrasound using SRUCC resulted in significant overestimation of degree of stenosis ..."