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Clinical Research

Feasibility and Reliability of Nonexpert POCUS for Cardiovascular Preparticipation Screening of Varsity Athletes: The SHARP Protocol

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ABSTRACT

Background: Point of care ultrasound (POCUS) is a potential adjunctive cardiovascular preparticipation screening modality for young competitive athletes. A novel cardiac POCUS screening protocol, Screening the Heart of the Athlete Research Program (SHARP), was developed for nonexpert examiners to assess common structural etiologies associated with sudden cardiac arrest/death (SCA/D).

Methods: Assessment of primary outcomes of feasibility, and reliability of obtained measurements, performed by comparison to formal transthoracic echocardiogram was undertaken. Inter-rater reliability was based on Intraclass correlation coefficients (ICC) defined as moderate for 0.40 to 0.59, good for 0.60 to 0.79, and excellent for 0.80 or greater. Electrocardiograms (ECGs) were also obtained. Identification of disease or other abnormalities was a secondary outcome.

Results: Fifty varsity athletes at our institution underwent the SHARP

RÉSUMÉ

Contexte : L'échographie au point de service (ou « POCUS », pour « point of care ultrasound ») est une modalité d'appoint pouvant servir au dépistage des troubles cardiovasculaires chez les jeunes athlètes avant leur participation à des compétitions. Un nouveau protocole de dépistage cardiaque par POCUS, le « Screening the Heart of the Athlete Research Program » (SHARP), a été élaboré pour permettre à des examinateurs non experts d'évaluer les étiologies structurelles communes associées à l'arrêt cardiaque soudain (ACS) et à la mort soudaine d'origine cardiaque (MSC).

Méthodologie : Les critères principaux, la faisabilité et la fiabilité des mesures obtenues, comparativement aux résultats produits par une échocardiographie transthoracique classique, ont été évalués. La fiabilité inter-évaluateur a été calculée à partir du coefficient de corrélation intra-classe et était modérée lorsque la valeur était

Preparticipation cardiovascular screening (PPCVS) of young competitive athletes (YCA) to prevent sudden cardiac arrest or death (SCA/D) is recommended by the majority of major medical and sporting organizations including the American Heart Association (AHA), American Medical Society for Sports Medicine (AMSSM), and International Olympic Committee and is being undertaken with a high degree of variability in Canada's universities.[1-5] Sudden cardiac death (SCD) is the leading medical cause of death among competitive athletes.[6] Research on the incidence of events and the effectiveness of cardiovascular preparticipation screening, however, has yielded varying results. The overall incidence of SCD in YCA is thought to be between 1:40,000 and 1:80,000, but—as recent publications from Canada and the United Kingdom demonstrate—these values still vary substantially in different populations with an incidence of 1:14,794 in the UK study and 1:131,578 in the Canadian study.[6-8] This variation occurs among ethnicities and among sports and is due, in part, to methodological concerns with data collection.[9,10]

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protocol, with 19 undergoing formal transthoracic echocardiogram and ECG for comparison. POCUS image quality was good to excellent. Feasibility of assessing for hypertrophic cardiomyopathy, aortic root dilatation, and left-ventricular function was deemed highly possible but limited in 20% for right-ventricular assessment. Reliability was good for measurements of interventricular septal thickness (0.67), end diastolic left-ventricular diameter (0.61), aortic root diameter (0.63), and moderate for left-ventricular posterior wall thickness (0.42). No cardiovascular abnormalities were detected.

Conclusions: A novel, comprehensive SHARP POCUS protocol performed by nonexpert practitioners demonstrated feasibility and reliability to assess varsity level athletes for common structural etiologies associated with SCA/D. Further large athlete screening cohort studies are required to validate the SHARP protocol and the role of cardiac POCUS as a screening modality.

comprise entre 0,40 et 0,59, bonne lorsque la valeur était comprise entre 0,60 et 0,79, et excellente lorsque la valeur était égale ou supérieure à 0,80. Des électrocardiogrammes (ECG) ont également été obtenus. Le repérage d'une maladie ou d'autres anomalies était un critère d'évaluation secondaire.

Résultats : Cinquante athlètes de niveau universitaire de notre établissement ont suivi le protocole SHARP, dont 19 ont subi une échocardiographie transthoracique standard et un ECG à des fins de comparaison. La qualité de l'image obtenue par POCUS allait de bonne à excellente. La faisabilité de l'évaluation de la cardiomyopathie hypertrophique, de la dilatation de la racine aortique et de la fonction ventriculaire gauche a été jugée excellente, mais limitée à 20 % pour la fonction ventriculaire droite. La fiabilité était bonne pour les mesures de l'épaisseur du septum interventriculaire (0,67), le diamètre diastolique ventriculaire gauche (0,61) et le diamètre de la racine aortique (0,63), et modérée pour l'épaisseur de la paroi postérieure du ventricule gauche (0,42). Aucune anomalie cardiovasculaire n'a été décelée.

Conclusions : Un nouveau protocole SHARP POCUS exhaustif pouvant être mis en œuvre par des praticiens non experts a démontré la faisabilité et la fiabilité de son utilisation pour évaluer, chez des athlètes de niveau universitaire, des étiologies structurelles communes associées à l'ACS ou la MSC. Des études plus poussées, portant sur des cohortes d'athlètes de plus grande taille, seront nécessaires pour valider le protocole SHARP et l'utilité du POCUS cardiaque en tant que modalité de dépistage.

Despite widespread endorsement, the choice of modality(ies) and comprehensiveness of PPCVS is highly debated and centred on the inclusion of a 12-lead electrocardiogram (ECG). Proponents of an ECG inclusive strategy cite low levels of sensitivity of history and physical examinations, reported at 20% and 9%, respectively, along with relatively high levels of sensitivity and specificity associated with ECG screening (94% and 93%, respectively).[11] Opponents find that these values result in an unacceptably high numbers of false positives, leading to a large burden of downstream testing and increased costs, particularly given a lack of a definitive mortality benefit.[4]

The use of formal echocardiography as a screening modality has not been considered feasible from a cost and infrastructure perspective. This is despite high rates of sensitivity and improved specificity for several common structural causes of SCD.[4] Formal echocardiography has demonstrated the ability to detect conditions missed on other modalities and detect other structural disease that may not be associated with SCA/D in YCA but has prognostic significance, such as bicuspid aortic valves, referred to as "secondary diagnoses."[12-14] Historically, the assessment of echocardiography as a preparticipation screening modality has referred to formal echocardiography. Formal echocardiography, by definition, is performed and interpreted by experts and involves a detailed analysis of all structures and function as well as documentation and knowledge regarding findings other than those prompting the examination.[15]

The rapid emergence and uptake of point-of-care ultrasound (POCUS) has made ultrasound vastly more affordable and accessible to a wide variety of practitioners.[16] Cardiac POCUS (also known as focused cardiac ultrasound [FCU], or hand-held cardiac ultrasound [HHCU]) differs from formal echocardiography—either limited or complete—in that the role of a POCUS examination is defined by the ability to "identify the presence or absence of 1 or several specific finding by using a defined, pre-established image acquisition protocol."[15] POCUS can be performed by both "nonexperts" and "experts," as defined by training requirements. The use of cardiac POCUS as an adjunct modality in preparticipation screening holds the potential to both improve sensitivity and specificity for the diagnosis of structural cardiac conditions predisposing athletes to SCA/D, to reduce the overall cost of screening, and be readily accessible to primary care providers performing screening. In this context, cardiovascular POCUS is considered to enhance the cardiovascular physical examination and is considered distinct from limited transthoracic echocardiography (TTE) as defined by Johri et al,[17] Ultrasound devices used for cardiac POCUS examination vary from more traditional, bulkier ultrasound machines, to recently developed ultraportable, or hand-held devices. The most notable device used in the limited cardiac POCUS preparticipation screening studies is the Vscan (Vscan; GE Healthcare, Chicago, IL).

Several studies have demonstrated the feasibility of expert cardiac POCUS/limited formal echocardiography as an adjunct screening modality with the use of an ultraportable device.[18-20] A nonexpert cardiac POCUS or "limited portable echocardiography by a frontline physician (PEFP)" protocol, the Early Screening for Cardiac Abnormality with Preparticipation Echocardiography or ESCAPE,[21,22] has also been developed. The ESCAPE protocol uses a single left parasternal long-axis view to obtain measurements of left-ventricular wall thickness and aortic root diameter as a screen for hypertrophic cardiomyopathy and aortic root dilatation and has shown to have strong correlation to formal echocardiography when performed

by sports medicine physicians.[23,24] Cardiac POCUS limited to a single parasternal view, however, has the potential to limit its sensitivity. Screening for findings of arrhythmogenic right-ventricular cardiomyopathy (ARVC), coronary artery anomalies (CAA), and apical variant hypertrophic cardiomyopathy (HCM) would be missed. Apical variant HCM was recently found to be ~50% of all HCM cases in nonwhite patients, substantially higher than previous studies of mainly white American populations.[25,26] A single image has the potential to be off-axis/suboptimal, and assessment of subsequent views can help obtain an optimized assessment. At present, no standardized or guideline-based cardiac POCUS screening protocol by noncardiologists for athletes exists, and, if used, varies by institution.[27]

A novel cardiac POCUS protocol (screening the heart of an athlete program or [SHARP]) for nonexpert practitioners/front-line physicians was developed to attempt to improve the sensitivity and specificity of cardiac POCUS used for PPCVS (Table 1). The use of ultraportable or hand-held ultrasound devices for nonexpert cardiac POCUS in this population has not previously been reported.

Methods

Study design was composed of 2 phases: an initial feasibility assessment (Phase I), followed by a second phase (Phase II) to assess reliability by comparison of measurements obtain by POCUS to those obtained on formal transthoracic echocardiograms. In Phase II, 12-lead ECGs were performed to assess if cardiac POCUS could reduce potential false positives obtained with ECG screening as a secondary outcome. Cardiac diagnoses obtained, either primary or secondary, was considered a secondary outcome.

For the initial feasibility component, 50 athletes participating in 12 varsity athletic sports were prospectively enrolled following written informed consent. Similar to previous imaging feasibility studies, a sample size of 50 was chosen to assess the primary feasibility outcomes of image quality and time required.[21,22] Subjects were recruited on a volunteer basis through poster advertisement, direct approach during various practice times, and e-mail. No incentive to participate was offered. Research Ethics Board of Queen's University approval was obtained.

The SHARP POCUS protocol (Table 1) was developed to screen for common structural causes of SCA/D in athletes that could be reasonably assessed for, taking into account limitations of a hand-held device and the noncardiologist examiner.[10,21,28] Images were obtained and analyzed in real time with measurements performed offline using the Vscan gateway software, All measurements were obtained on a frozen-frame parasternal long-axis (PLAX) view at end diastole, identified through visual assessment of the frame with the largest left-ventricular diameter. Protocol measurements included three targeted at screening for HCM: end diastolic interventricular septal thickness (IVSd), end diastolic LV posterior wall thickness (LVPWd), and end diastolic left-ventricular diameter (LVDd) (Fig. 1). Measurement of aortic root diameter at sinus of Valsalva level was obtained. The measurements used to assess HCM and aortic root dilatation have been validated previously for noncardiologists, and established normal limits for athletes were used to assess abnormalities (Table 2).[23,24,29] The right ventricle was assessed for aneurysmal dilatation, or bulging, and assessed as either normal or abnormal requiring further assessment. Overall left-ventricular function and valvular function of the aortic and mitral valve, which included assessment for valvular regurgitation by colour Doppler, was assessed again by a dichotomous assessment of normal or abnormal, requiring further assessment.

The POCUS studies were performed by a noncardiologist physician (internal medicine resident physician in second year of postgraduate training) with no previous echocardiographic training. The resident underwent a 15-hour formal focused

Table 1. SHARP POCUS protocol

Views	Measurements*
1. Parasternal long-axis a. Colour Doppler aortic valve b. Colour Doppler mitral valve 2. Parasternal short-axis a. Aortic valve level b. Mitral valve level c. Papillary muscle level d. Apex 3. Apical 4-chamber	1. Interventricular septal thickness end diastole (IVSd) 2. Left-ventricular posterior wall thickness end diastole (LVPWd) 3. Left-ventricular internal diameter end diastole (LVIDd) 4. Aortic root diameter a. Sinuses of Valsalva

POCUS, point-of-care ultrasound; SHARP, screening of the heart of the athlete research program.

*Obtained from parasternal long-axis view.

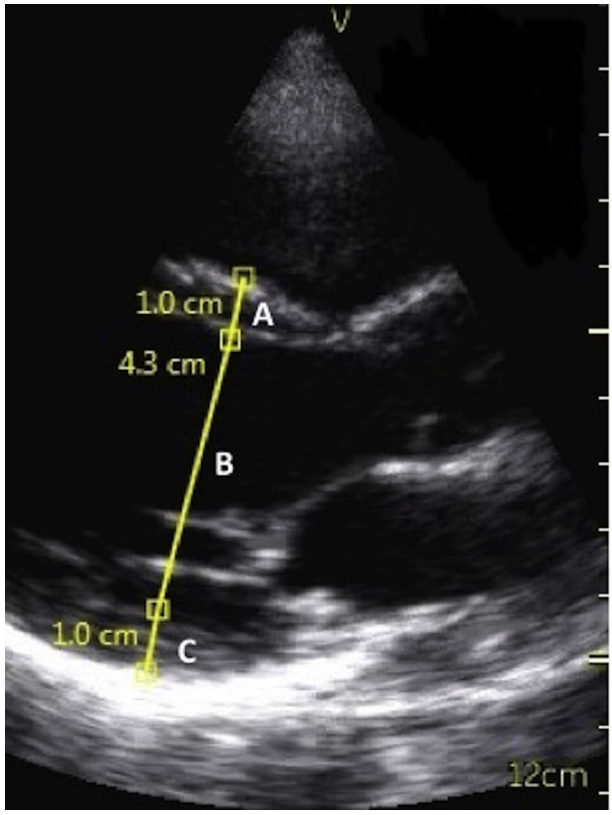

Figure 1. Sample parasternal long-axis view obtained with ultraportable Vscan device (GE Healthcare, Chicago, IL) with offline-obtained measurements. (**A**) interventricular septal thickness end diastole; (**B**) left-ventricular internal diameter end diastole; (**C**) left-ventricular posterior wall thickness end diastole.

Table 2. Criteria for normal POCUS in athletes

Parameter	Male reference value	Female reference value
IVSd (mm)	< 14	< 13
LVIDd (mm)	< 64	< 58
LVPWd (mm)	< 14	< 13
Aortic root (mm)	< 39.1	< 37.2
IVSd: LVPWd (ratio)	< 1.3	< 1.3

Reference values take into account normal physiologic remodelling for high-performance athletes.

IVSd, interventricular septal thickness end diastole; LVIDd, left-ventricular internal diameter end diastole; LVPWd, left-ventricular posterior wall thickness end diastole; POCUS, point-of-care ultrasound.

Adapted from Weiner et al.[29] and Yim et al.[24]

cardiac ultrasound course, 30 hours of hands-on scanning training by certified sonographers, and self-directed practice including the use of a simulator (CAE Vimedix, Saint-Laurent, QC). The primary feasibility outcomes were ability to screen for structural causes of SCD based on image quality and time required to obtain each study. Secondary outcomes were incidence and type of cardiovascular abnormalities detected.

Image quality was assessed by a level III echocardiographer (as defined by the Canadian Society of Echocardiography) and evaluated using a 4-point quality scale (1 = excellent, 2 = good, 3 = fair, 4 = poor). This rubric for assessing quality and feasibility of POCUS has been previously established by our group (Cardiovascular Imaging Network at Queen's [CINQ], www.CINQlab.com).[30] Seven parameters, including image quality, ability to assess disease states, and quality of measurements were assessed. Images were reviewed for abnormalities requiring further assessment.

To assess reliability, all 50 original participants were invited to undergo ECGs, and a formal transthoracic echocardiogram performed and analyzed on a full-service machine (Vivid, GE Healthcare, Chicago, Illinois) by a level II echocardiographer. Primary outcome for reliability assessment of the SHARP POCUS protocol was comparison to formal echocardiography through the use of intraclass correlation coefficients (ICCs) (IBM SPSS version 24.0 for Windows, Armonk, New York). Secondary outcomes included the identification of disease or abnormalities by either the ECG or formal echocardiography. Inter-rater reliability was defined as moderate for 0.40 to 0.59, good for 0.60 to 0.79, and excellent for 0.80 or greater,[31] Participants were required to undergo a separate consent process for Phase II and a separate ethics approval was obtained from the Research Ethics Board of Queen's University. An incentive of a gift card valued at $25 Canadian was provided for participation in Phase II.

Results

For Phase I, the target number of 50 athletes was achieved. Average age of the participants was 20.2 years (18 to 25 years old), with 58% female athletes and 82% identifying as white. Athletes participated in 12 different sports, including basketball (14), rugby (9), rowing (6), football (5), and ice hockey (4). All athletes were healthy and denied a history of cardiac disease. One athlete reported history of a heart murmur and a previously normal echocardiogram.

Average time for the POCUS examination was 11:42 minutes ± 3:11 minutes (including setup and appropriate draping). Feasibility results are displayed in Table 3. Overall study quality and assessment of HCM, aortic root dilatation, and overall left-ventricular function was deemed highly feasible. Feasibility of assessing right-ventricular abnormalities (as a screen for ARVC) yielded an average score of 1.8 ± 0.8, with 9 scans receiving a fair score and 1 a poor score. No cardiovascular abnormalities were detected that required follow-up.

For Phase II, 19/50 athletes agreed to participate and underwent ECG and formal echocardiography. Four ECGs showed evidence of LVH by voltage criteria, and 1 had evidence of left-atrial enlargement. These are all considered normal findings in athletes based on the 2017 International ECG interpretation standards for athletes.[32] Reliability was found to be good for measurements of IVSd, LVIDd, and aortic root diameter, and moderate for LVPWd (Table 4). Average measurements obtained from nonexpert POCUS and formal echocardiography as displayed in Table 4.

Discussion

The optimal PPCVS strategy for YCA has yet to be established. The majority of underlying etiologies predisposing YCA to SCA/D in this age group are genetic.[10,28] The use of cardiac imaging and, in particular, echocardiography has been seen as experimental and unfeasible, owing to high associated costs and lack of appropriate infrastructure.[33] Despite a rapidly growing body of work on the subject, recently published guidelines pertaining to echocardiography and PPCVS, defer a discussion of appropriateness of its inclusion in screening programs.[34]

Formal echocardiology requires highly trained cardiologists and/or sonographers for image acquisition and interpretation and, on its own, is relatively insensitive in detecting conditions associated with SCA/D.[8] This is due in part to only 40% of etiologies being considered structural in nature and the varying age of phenotypic expression of several conditions.[8,28]

The potential benefits of nonexpert cardiac POCUS in PPCVS is the provision of cardiac imaging to enhance the physical examination, with the potential to improve the specificity and sensitivity of a multimodal screening program.[27] There is potential for reduction of costs associated with unnecessary follow-up testing, reducing athlete anxiety regarding false positive results, and improving diagnostic capabilities of screening programs for structural heart disease predisposing to athletes to SCA/D if physical examination in this regard can be improved. Lower costs would allow for its

Table 3. Feasibility assessment

Parameter	Results*
Overall study quality	1.5 ± 0.6
Parasternal long-axis image quality	1.1 ± 0.3
Assessment for HCM	1.1 ± 0.3
Assessment for ARVC	1.8 ± 0.8
Assessment for aortic root dilatation	1.0 ± 0.1
Assessment for overall LV function	1.1 ± 0.3
Measurements appropriate	49/50 studies

ARVC, arrhythmogenic right ventricular cardiomyopathy; HCM, hypertrophic cardiomyopathy; LV, left ventricle.

*Results graded on 4-point quality scale (1 = excellent, 2 = good, 3 = fair, 4 = poor).

Table 4. Measurements and reliability assessment

Parameter	Nonexpert POCUS: all athletes	Nonexpert POCUS: formal ECHO done*	Formal ECHO*	ICC
IVSd (mm)	9.9 ± 1.5	9.9 ± 1.6	8.5 ± 1.8	0.671
LVIDd (mm)	48.7 ± 5.1	48.3 ± 4.7	49.4 ± 3.8	0.615
LVPWd (mm)	10.7 ± 1.5	10.35 ± 1.4	8.75 ± 1.6	0.420
Aortic root (mm)	28.2 ± 3.7	29.2 ± 3.1	30.1 ± 3.2	0.627
IVSd: LVPWd (ratio)	0.9 ± 0.15	0.9 ± 0.15	0.9 ± 0.20	n/a

Values are mean ± standard deviation.

ECHO, transthoracic echocardiogram; ICC, intraclass correlation coefficient; IVSd, interventricular septal thickness end diastole; LVIDd, left-ventricular internal diameter end diastole; LVPWd, left-ventricular posterior wall thickness end diastole; POCUS, point-of-care ultrasound.

*ICCs calculated from comparison of values of subset of athletes who had formal ECHO performed.

use in repeated screening, detecting cardiac conditions as they phenotypically present.

Our study demonstrates that a more comprehensive cardiac POCUS protocol performed by noncardiologists is feasible to screen for major structural causes of SCA/D including HCM, dilated cardiomyopathy, and aortic root dilatation, with image quality near excellent for screening wall thickness, aortic root assessment, and overall left-ventricular function (Table 3). Appropriate measurements pertaining to HCM and aortic root diameter were obtained in 95% of examinations. Our study is the first to assess feasibility of right-ventricular assessment by a nonexpert cardiac POCUS protocol in the YCA preparticipation screening setting. Image quality obtained to assess for right-ventricular function as a screen for ARVC was judged to be fair or poor in 20% of cases, suggesting a possible limitation of our POCUS protocol as a screen for ARVC. A subcostal 4-chamber view may also be more appropriate to obtain higher-quality RV images by nonexperts and should be considered in future iterations of our protocol.

Assessment for valvular function and pathology by visual colour Doppler assessment of the aortic and mitral valves was done on the parasternal long-axis view. These views were performed to assess for obvious regurgitant lesions associated with underlying structural pathology and thereby increase the sensitivity of the exam (ie, aortic regurgitation from aortic root dilatation). Assessment of stenotic lesions or mitral valve prolapse was considered beyond the scope of our protocol. Assessment for a bicuspid aortic valve, however, was included and performed on the parasternal short-axis view at the aortic valve level. Images obtained were believed to be appropriate to assess for this limited valvular pathology screen.

Reliability was found to be good for IVSd, LVIDd, and aortic root diameter and moderate for LVPWd (Table 4). These results are consistent with previous studies with nonexpert operators, and novel in demonstrating reliability with the use of an ultraportable device.[23,24]

Cardiac POCUS, however, is not without limitations. Standardized training recommendations and guidelines have yet to be developed to ensure quality control among those performing POCUS in general, let alone specific cardiac screening standards. POCUS is typically performed on ultrasound machines with fewer capabilities and lower image quality than those of formal ultrasound or echocardiography. The use of POCUS may also have a paradoxical effect of increasing referrals for false positives, either if inadequate training is obtained or from limitations of the modality.[35] Despite these drawbacks, the development of machine-learning technology along with cloud storage and open access data has the ability to involve POCUS in a revolution of medical imaging and care, making it easier for nonexperts/primary care physicians to use POCUS technology more accurately and efficiently.[27] In the cardiac-screening realm, machine-learning algorithms have already been developed to help assist in the discrimination of physiologic vs pathologic hypertrophic remodelling in athletes.[36]

Cost considerations

The addition of POCUS would add minimal cost to the payer of an established screening program when considered part of the physical examination. The upfront cost of a contemporary device, which includes the necessary software, is currently ~$8000 CAD. This is expected to drop dramatically to ~$2000 per device (Butterfly IQ, Butterfly Network Inc., Guilford, CT). However, the cost of such a device would be shared by other services that a POCUS-oriented physician may provide outside of a screening program. At present, not enough data exist on the diagnostic validity of POCUS in a multimodality cardiovascular screening program (or otherwise) to assess its impact on cost effectiveness, although it would be of great interest for future study.

Clinical impact

The Canadian Cardiovascular Society and Canadian Heart Rhythm Society have recently endorsed a Position Statement on cardiovascular screening in the YCA, (personal communication, A.M.J). They present a tiered approach in which a foundation of emergency protocols, expert support, and shared decision making are present before considering screening components such as history, physical, and ECG. Notably, advanced screening maneuvers, such as blanket ECG, are not recommended as first line. In the same manner, the use of a cardiac POCUS protocol may be implemented by the physician (cardiologist or noncardiologist) overseeing this screening program for athletes who have been flagged during the history, as part of the physical examination, rather than a blanket routine ultrasound screening maneuver. This tool provides an enhancement of the physical examination for patients for whom there is concern, allowing the sports physician to make a more informed decision with respect to further downstream testing. Also, implementation of standardized, consistent preparticipation screening in Canadian organizations and universities will serve as a foundation for a systematic approach to cardiovascular care of athletes.

Limitations

There are several identifiable limitations. The feasibility component was limited in size, and only 38% of participants followed up to have formal echocardiograms done for comparison. No cardiac diagnoses were obtained on screening, and therefore no assessment of operator skill in detecting conditions or abnormalities being screened for can be made. This study was inadequately powered in the event of disease detection to comment on validity of POCUS. This, however, is not dissimilar to other feasibility and reliability POCUS studies, in which, given the limited sample size and low levels of disease prevalence, disease detection would be of low probability.[21,22] The population screened was not a high-risk one, based on ethnicity and sport preference.[9] Limitations of the SHARP protocol itself, as discussed above, include assessment of the right ventricle in ~20% of scans. No assessment for coronary artery anatomy was obtained or was thought to be feasible. However, assessment of coronary artery origins in YCA performed with screening formal echocardiography performed by cardiologists has recently been shown to be feasible in 98% of athletes.[37] As coronary artery anomalies account for approximately 10% of structural SCA/D (4% overall), further assessment of cardiac POCUS in this regard should be undertaken. Limitation of the ultraportable device (Vscan) was also found to be ease of obtaining measurements online. Owing to device constraints and concerns regarding accuracy, measurements were obtained offline using the Vscan gateway software, leading to additional overall time for complete study. Finally, the ultimate goal of the SHARP protocol is to reduce false positives detected by current screening practices (history, physical, and ECG) to reduce costs, unnecessary testing, and concern by the athlete. Such a goal would require a larger multicentre study to assess the impact of the SHARP protocol on downstream resource utilization and costs. Our study is a proof-of-concept that points the way for such a study.

Conclusion

The SHARP POCUS protocol, when performed by nonexpert practitioners, demonstrates both feasibility and reliability to assess varsity level athletes for common structural etiologies associated with SCA/D. Similar studies of cardiac POCUS performed by primary care physicians, as a preparticipation screening modality, have been limited to a single parasternal long-axis view to assess HCM and aortic pathology. The SHARP protocol is more comprehensive and assesses multiple structural abnormalities, with the potential to improve sensitivity and specificity of preparticipation cardiac screening physical examination when performed in conjunction with a multimodal screening strategy. Further large athlete screening cohort studies are required to validate the SHARP protocol and assess the role of cardiac POCUS for screening YCA for structural etiologies predisposing to SCA/D.

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