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Use of ultrasound by registered nurses—a systematic literature review

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Use of ultrasound on the inferior vena cava by renal nurses – A systematic literature review

INTRODUCTION

In Western Australia (WA) satellite dialysis units, no doctors are on-site during treatment hours, which means nurses have to make clinical decisions about fluid removal, a crucial determinant of a patients' well-being and morbidity. Renal nurses have a central role in determining the fluid status of their patients as they see them at least three times per week for a haemodialysis (HD) treatment, far more often than renal consultants (Chamney, 2007, San Miguel, 2010). Renal nurses must assess each patient and then deliver a treatment using an individualised approach (Chamney, 2007, Bradshaw and Bennett, 2015). Fluid removal during haemodialysis is essential for maintaining the overall condition of patients with end stage renal disease (ESRD) as most of these patients have only minimal urine production. At the start of each session the renal nurse performs a clinical assessment of a patient's fluid status, based on a patient's body weight, blood pressure and any clinical signs of fluid overload such as oedema (swollen ankles or legs), shortness of breath (SOB) or elevated jugular venous pressure (Mahon et al., 2013). Haemodialysis patients can experience adverse intradialytic events often due to symptomatic intradialytic hypotension (IDH)(Burton, 2009). Growing evidence shows that IDH, even when asymptomatic, places a patient at risk of end organ damage, mainly cardiovascular (Davenport, 2014). Occurrence of IDH also increases the risk of vascular access thrombosis (VAT). Chang et al. (2011) concluded that an increased frequency of IDH in combination with lower pre-dialytic systolic blood pressure (BP) results in a higher rate of VAT. This is critical for haemodialysis patients as their arteriovenous fistula (AVF) is their only option for connecting to the dialysis machine (Sherman and Kapoian, 2011, Mahon et al., 2013). Each episode of IDH implies recurrent systemic circulatory stress on various organ systems like the heart, brain, gastrointestinal tract (GIT) and the kidneys (McIntyre, 2010). These critical and potentially damaging events are frequently missed by renal physicians who generally only see a patient on a three monthly basis (Schiller et al., 2015). Schiller et al. (2015) also claim that "the dialysis community has tacitly accepted the idea that IDH is an innate feature of the HD treatment and has failed to prioritise its prevention". These authors also raise that doctors in training are still taught that a dialysis prescription mainly has to focus on achieving a minimum Kt/V target (Kt/V is a measure of dialysis adequacy in respect to solute removal, with K being the dialyser clearance of urea, t - reflecting dialysis time and V implying the volume of distribution of urea, normally the body water), rarely targeting IDH and its possible negative consequences. The authors suggest a "volume first approach" and "zero tolerance for IDH" to advance patients' cardiovascular health. IDH remains one of the most frequent adverse events for patients with ESRD undergoing regular haemodialysis treatments and has variously been reported to occur in between 15 and 20% of all treatments(Daugirdas, 2014). Santos et al. (2012) identified a subgroup consisting mainly of diabetics or elderly patients suffering from cardiac disease experiencing symptomatic IDH episodes during up to 50% of their treatments, predicting that this subgroup will significantly grow in future. This highlights the point that today, 70 years after the first haemodialysis treatment was undertaken by Willem Kolff (Ellis, 2007), the dialysis community is still struggling to deliver an incident-free treatment to their clients.

Several studies have demonstrated that ultrasound measurement of the inferior vena cava (IVC-US) is a non-invasive and rapid method when assessing the intravascular volume status of a patient (Panebianco et al., 2014, Guiotto et al., 2010, Seif et al., 2012, Thanakitcharu et al., 2013).This

method has also been successfully applied on haemodialysis patients and it has been described as an effective tool for non-invasive volume management (Brennan et al., 2006). Although being characterized unsuitable as a sole parameter for fluid status, IVC-US may be an essential addition to fluid assessment and may help to complete a more detailed interpretation of hydration of patients on haemodialysis (Krause et al., 2001). To our knowledge, IVC-US has to date been only used by the medical profession or in other nursing specialities, but while renal nurses spend significant time with their clients and make daily critical clinical decisions on fluid assessment, it must be asked if they could use this objective method for improved clinical outcomes. Therefore, we hypothesize that renal nurses could potentially use IVC-US to add another clinical dimension when estimating ultrafiltration (UF) goals for haemodialysis patients.

AIM

The systematic literature review aimed at examining the existing literature in regards to the use of IVC-US by renal nurses for intravascular volume assessment and for the prevention of IDH. It was intended to find evidence, if renal nurses could potentially use abdominal ultrasound on the inferior vena cava as a more comprehensive approach and add another objective parameter to assess the intravascular volume status in haemodialysis patients. Additionally, it was targeted to find articles on the general use of ultrasound by nurses in the renal speciality.

METHODS

A systematic literature review was performed to search for relevant publications addressing the use of IVC-US by nurses for volume assessment. Searched databases included CINAHL Plus with Full Text, SCOPUS, Web of Science and MEDLINE using the terms “intradialytic hypotension prevention” (= Search term 1 or S1), “ultrasound haemodialysis” (S2), “ultrasound inferior vena cava” (S3) and “intradialytic hypotension” (S4). The search terms S2, S3 and S4 were then combined with the term “nurses”. The search was limited to full-text articles only and where references were available. Publication dates ranged from 1996 to 2015. Peer-reviewed academic journals, renal registries, case reports, retrospective audits, non-randomized clinical trials and doctoral dissertations were included in the global search. Languages other than English and pre 1996 articles were excluded from the review. Additionally, articles and reviews not meeting minimum quality requirements, such as lacking peer review or not including an abstract were excluded too.

RESULTS

The initial search within all four databases yielded 4372 non-duplicate citations which were subsequently screened (Figure1). Applied inclusion and exclusion criteria reduced the number of eligible articles to 175. After the repeated application of exclusion and inclusion criteria and a full text screen another 83 articles were excluded. Further 78 articles were excluded during data extraction as they did not provide enough statistical evidence or were considered irrelevant to the main topic of nurses or novices potentially using ultrasound for volume assessment or the prevention of IDH. The systematic literature review resulted in a final number of 14 articles which met inclusion criteria. Table 1 presents a summary of these 15 articles.

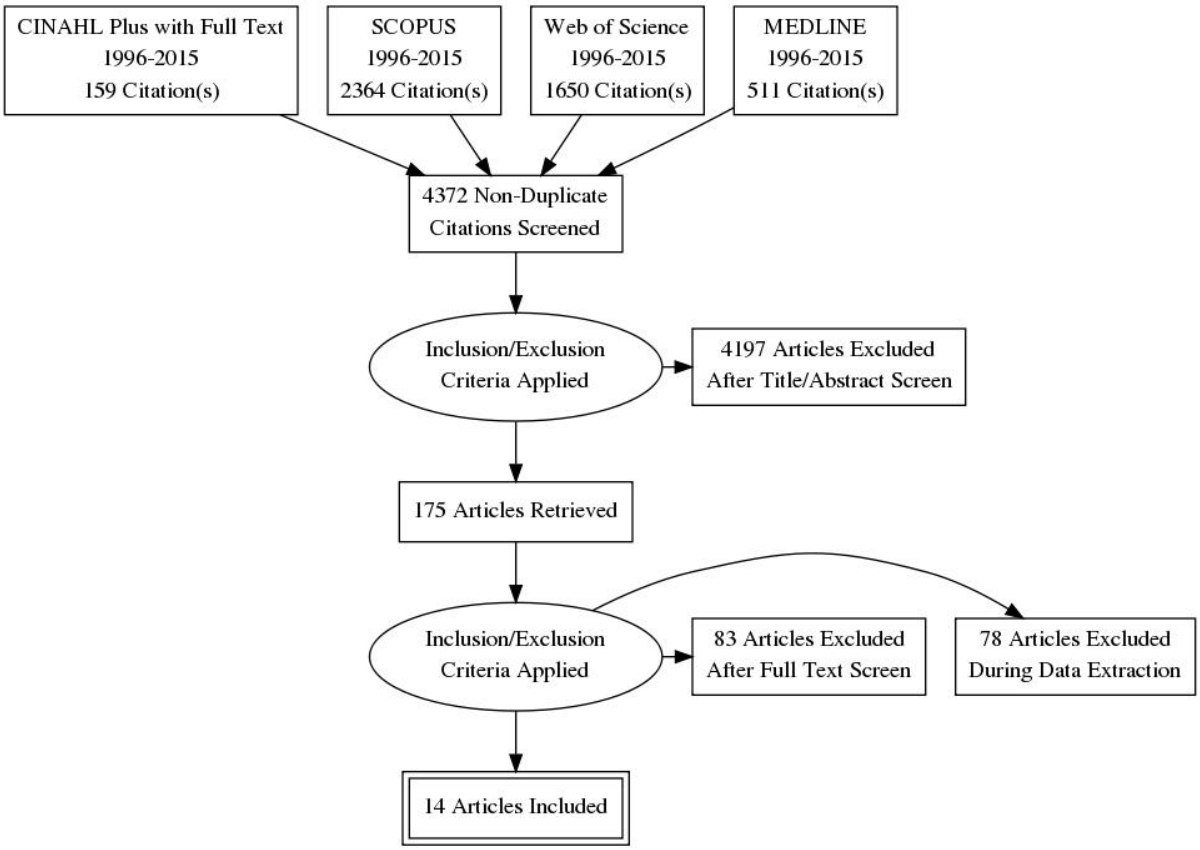

Figure1. Results of systematic literature review by searching 4 databases (CINAHL plus, SCOPUS, Web of Science, MEDLINE)

	Author (year), Title	Study design	Sample size and sites	comments/key findings
1	Brennan, J.M. (2006).”Hand-carried ultrasound measurement of the inferior vena cava for assessment of intravascular volume status in the outpatient hemodialysis clinic”.	Prospective observational study of IVC measurements performed by medical residents with minimal previous echocardiographic exposure, followed by a competent sonographer	89 patients in 2 hemodialysis outpatient clinics assessed on IVCd before and after HD	Hand-carried ultrasound measurement of the IVC is a feasible option for rapid assessment of intravascular volume status in an outpatient dialysis setting by operators with limited formal training in echocardiography
2	Thanakitcharu,P. (2013).”Inferior vena cava diameter and collapsibility index: a practical non-invasive evaluation of intravascular fluid volume in critically-ill patients”.	Prospective cross-sectional study to evaluate IVCd as a guidance for estimation of the volume status in comparison to central venous pressure (CVP)	70 critically-ill patients in an intensive care unit (ICU)	Good correlation between CVP and IVCd and can provide a useful guide for noninvasive intravascular volume status assessment
3	Marticorena, R.M.(2015)."Development of competencies for the use of bedside ultrasound for assessment and cannulation of hemodialysis vascular access".	Continuing professional development activity for renal nurses	N/A	Use of ultrasound for hemodialysis vascular access assessment and real-time cannulation requires specialised training. Novices can achieve competency with daily use of ultrasound at the bedside. With approximately 500 guided cannulations the highest level of competency can be accomplished.

4	Schoch, M. (2015)."Utilising point of care ultrasound for vascular access in haemodialysis".	Continuing professional development activity	N/A	Use of point of care (POC) ultrasound by renal nurses has potential to decrease cannulation-related adverse events, but its use is sporadic. Non-invasive visualisation of intravascular conditions can have positive effects on patient comfort, nurse and patient satisfaction and longevity of vascular access life.
5	De Lorenzo, R.A. (2014)."Ultrasound measurement of inferior vena cava diameters by emergency department nurses".	Prospective educational study using pre- and posttest of knowledge and comparison of imaging performance between a subject and expert sonographer	14 Emergency Department nurses without formal ultrasound experience performed IVC-US (longitudinal and transverse) on 42 patients with subsequent comparison to measurements performed by an expert sonographer	Emergency department nurses with no prior sonography experience have the ability to learn IVC-US. After training, nurses show moderately good correlation measuring the IVC diameter compared to expert measurements. Nurses performed better when measuring the IVC in longitudinal orientation.
6	Fields, J.M (2011)." The Interrater Reliability of Inferior Vena Cava Ultrasound by Bedside Clinician Sonographers in Emergency Department Patients".	Prospective observational study examining interrater reliability between emergency physician sonographers in a convenience sample of emergency department patients.	5 Emergency physicians performed 92 paired IVC-US exams on 46 patients	Emergency physicians' measurements of the IVC-US have a high degree of interrater reliability. IVC percent collapse by visual estimation show lower but still moderate to good reliability
7	Guiotto, G. (2010).”Inferior vena cava collapsibility to guide fluid removal in slow continuous ultrafiltration”.	Prospective, observational study	Measurement of IVCd and IVCCI in 24 ICU patients during slow continuous ultrafiltration by four cardiologists with 2 years ultrasound training	IVC-US is rapid, simple and non-invasive for bedside monitoring of intravascular volume and may guide fluid removal rate
8	Sönmez, F. (1996).”The adjustment of post-dialysis dry weight based on non-invasive measurements in children”.	Prospective, observational study	Measurement of IVCd and IVCCI in 12 HD patients (children) before and after HD	Increased IVCd and decreased IVCCI due to overhydration. IVC-US may be a novel non-invasive method for IBW assessment
9	Schoch, M. (2012)."Advanced vascular access workshop for dialysis nurses: a three-year review".	Retrospective three-year review of a vascular access workshop in Victoria / Australia	73 responses to an evaluation survey upon completion of the vascular access workshop, scoring theoretical, practical and guest speaker content	Ongoing demand for continuing renal education with a focus on vascular access surveillance and cannulation of AVF. Renal nurses can learn during a three day workshop the use ultrasound for vascular surveillance and guided needle cannulation.
10	Dalen, H. (2014)."Feasibility and reliability of pocket-size ultrasound examinations of the pleural cavities and vena cava inferior performed by nurses in an outpatient heart failure clinic".	Prospective study of pocket-sized imaging device (PSID) examinations on pleural cavities and inferior vena cava performed by specialised nurses in a heart-failure clinic.	2 specialised nurses (both previously performed >200 focused ultrasound examinations of the IVC and pleural cavities) performed ultrasound scans on pleural cavities and on the IVC of 62 patients, with subsequent comparison to cardiologists	Implementing focused ultrasound examinations to assess volume status by nurses in an outpatient clinic may improve diagnostics and subsequently therapy. After dedicated training nurses in a heart failure clinic can accurately assess for fluid in the pleural cavities and measure the IVC (dimension and collapsibility) to assess a patients’ volume status with a PSID. Authors advise caution to transfer IVC-US to less experienced users.
11	Gustafsson, M.(2014)."Pocket-sized ultrasound examination of fluid imbalance in patients with heart failure: A pilot study of heart failure nurses without prior experience of ultrasonography".	Pocket-sized ultrasound (PSUD) examinations on pleural cavities and inferior vena cava performed by specialised nurses in a heart-failure clinic, with subsequent assessment by an expert cardiologist.	4 specialised nurses (experience in heart failure care, but without prior ultrasound experience) performed ultrasound scans on 104 patients	Following 4 hours of training in a PSUD, nurses were able to obtain information on the assessment and detection of pulmonary congestion and pleural effusion. For reliable IVC-assessment, training needs to exceed 4 hours.

12	Muniz Pazeli (2014)."Can Nephrologists Use Ultrasound to Evaluate the Inferior Vena Cava? A Cross-Sectional Study of the Agreement between a nephrologist and a Cardiologist".	Cross- sectional study of the agreement between a Nephrologist and a Cardiologist when performing IVC-US for volume assessment on haemodialysis patients	A convenience sample of 52 patients in an outpatient dialysis clinic investigated by a nephrologist and a cardiologist with a regular ultrasound system (RUS) and a cardiovascular ultrasound system	IVC-US can be performed by nephrologists with limited echocardiographic experience using an ordinary ultrasound machine. IVC-US could be a useful, non-invasive and repeatable modality for dry weight estimation in dialysis clinics. The skill, not the occupation of the operator, is the deciding factor.
13	Bauman,B.M. (2008)."Volumetric bladder ultrasound performed by trained nurses increases catheterization success in pediatric patients".	Randomized-controlled trial assessing the success rate of first-attempt conventional catheterization vs catheterizations after volumetric bladder ultrasound performed by 3 nurses	93 paediatric patients in a paediatric emergency department, 48 patients in the ultrasound group and 45 in the control group	Nurses with limited ultrasound training can perform volumetric bladder ultrasound and are able to accurately determine bladder volumes and appropriately use these measurements to guide catheterization attempts.
14	Sharp (2013)."Vein Measurement by Peripherally Inserted Central Catheter (PICC) Nurses Using Ultrasound: A Reliability Study".	Observational study of measurement of inter-rater reliability between a nurse and an expert when measuring calipers of brachialic, basilic and cephalic veins with ultrasound prior to PICC insertion	A PICC nurse with 10 years experience vs experienced ultrasonographer, measured 12 patients with 2 ultrasound observations per subject on the brachialic, basilic and cephalic vein	A suitably trained PICC nurse can reliably measure vein diameter using ultrasound. PICC nurses need appropriate training and ongoing support to ensure they use technology competently prior insertion of PICC

Table1. Summary table of articles: nurses use of ultrasound or use of ultrasound on the inferior vena cava for volume assessment or prevention of IDH

USE OF ULTRASOUND BY NURSES

Relevant literature concerning renal nurses' use of US to measure the IVC in haemodialysis patients was examined. No articles on renal nurses using US to measure the IVC were found, however several papers have concluded that nurses can successfully use ultrasound in a variety of other clinical settings (Baumann et al., 2008, Sharp et al., 2013, Dalen et al., 2014, Gustafsson et al., 2014, Schoch and Smith, 2012).

De Lorenzo and Holbrook-Emmons (2014) demonstrated that emergency department nurses with no previous skills in the use of US were able to measure the IVCd after a short training period. This study reported from 14 Emergency Department nurses performing IVC-US in longitudinal and transverse orientation of the probe on 42 patients. Their measurements showed a "moderately good correlation" with those by professional sonographers. The emergency department nurses performed better, when measuring the IVC in longitudinal orientation.

Baumann et al. (2008) demonstrated that nurses were competent to use bladder ultrasonography in a paediatric emergency department prior to a diagnostic catheterisation. It also showed that it is a preferable method compared to the emergency physician performing this task. Three paediatric nurses were trained in paediatric bladder ultrasound to increase the success rate prior to catheterisation of children of 3 years and under. A significant difference was found between the first-attempt success rate in catheterisation of 92% in the ultrasound group compared to 67% in the conventional catheterisation group.

During a study by Sharp et al. (2013) a nurse with 10 years' experience with peripherally inserted central catheters (PICCs) was successfully trained to perform ultrasound measurements on the basilic, brachial and cephalic veins. When compared to a sonographer, the measurements showed

a high intra- and inter-rater reliability. Therefore, it was concluded that PICC nurses could reliably measure vein diameters as long as they receive correct training and ongoing support.

Nurses in a heart failure clinic can accurately assess for fluid in the pleural cavities and measure the IVC to assess a patients' volume status with a pocket - sized imaging device (PSID). This study by Dalen et al. (2014) also showed, that specialised nurses were able to obtain and correctly interpret images from the IVC and the pleural cavities with the PSID. These nurses had previously performed >200 focused ultrasound examinations of the IVC and pleural cavities and were "at least moderately familiar with diagnostic ultrasound" according to the authors. Therefore, they recommended caution to assign these tasks to less experienced users.

In a study by Gustafsson et al. (2014) pleural effusion (PE) and IVCd were measured by four nurses with expert knowledge in heart failure care, but without any previous experience in the use of pocket-sized ultrasound. They were compared to an expert cardiologist in their findings of the IVCd, PE and B-lines (short-path reverberation artefacts which indicate sub pleural interstitial oedema). It was claimed that the sensitivity and specificity was high and there was also a high inter-operator agreement. Although there were difficulties in positioning the probe and sometimes the aorta was mistaken for the IVC, the authors suggest that the "implementation of pocket-sized ultrasound device examination as part of the clinical routine at a nurse-led heart failure outpatient clinic is feasible"(Gustafsson et al., 2014).

To date the renal nursing speciality uses ultrasound technology exclusively for the assessment of the arterio-venous fistula (AVF), which serves as the vascular access route for haemodialysis. It has been reported that the use of point-of-care (POC) ultrasound devices by renal nurses has the potential to reduce cannulation related adverse events, but it is still used only sporadically (Schoch et al., 2015).The authors claim that advantages of the use of POC for cannulation clearly outweigh the disadvantages and that the visualisation of intravascular conditions has multiple advantages. It may not only provide better patient comfort, but also lead to improved satisfaction for both, patient and nurse, and may enhance the lifespan of the AVF. Schoch and Smith (2012) argue that the demand by renal nurses for regular workshops, which focuses on vascular access surveillance, and cannulation of the AVF, highlights the ongoing need for education in renal nursing in Australia. Their primary goal is to enhance the skills of the renal nursing workforce with the addition of ultrasonography and to make nurses confident in using this technique. These authors illustrated that learning the use of ultrasound involves a steep learning curve for renal nurses and having success with the visualisation of the AVF, depends strongly on the user.

An article by Marticorena et al. (2015) describes bedside ultrasonography for assessing and cannulation of vascular access by renal nurses as a common practice in many HD units worldwide requiring specialized training. While basic ultrasound competencies are achievable by daily practice, it could take up to 500 ultrasound guided cannulations to reach the highest level of competency for a renal nurse.

The limited articles found on the use of IVC-US by renal nurses highlights the paucity of evidence in this area. A prospective study could therefore be valuable to investigate if renal nurses can use IVC-US in a clinical setting and its impact on patient outcomes. The use of IVC-US by renal nurses could potentially add significant value to the understanding of a patient's fluid status, reduce adverse outcomes and prevent unnecessary morbidity and mortality.

DISCUSSION

IDH remains a challenge for renal nurses on a day-to-day basis in haemodialysis units worldwide, even after 70 years of refining treatment methods in haemodialysis. A survey amongst the managers of 12 haemodialysis units in the United States found that 19% of their patients had two or more episodes of IDH within 30 days (Hossli, 2005) and that these multiple episodes decreased the adequacy of dialysis. Another study by Bradshaw et al. (2015) of 173 Australian and New Zealand renal nurses concluded that the majority were conscious that asymptomatic events of IDH can also generate serious damage, indicating that renal nurses are well aware of the multifaceted manifestations of IDH. The majority of the nurses identified the systolic blood pressure as the most important factor when assessing a patient for the existence or likelihood of IDH. In terms of preventative measures UF profiling was commonly applied. Blood Volume Monitoring (BVM) and/or a reduction in the dialysate temperature were applied by over 50% of the surveyed nurses. It was also stressed by these nurses, that continual individualized patient assessment through frequent monitoring during haemodialysis is needed. Bradshaw et al. (2015) suggest that longstanding care for chronic haemodialysis patients might make nurses more aware of specific patient's circumstances which could contribute to more positive patient outcomes. The authors concluded that renal nurses, despite many years of experience, have a requirement for recurrent and ongoing nephrology education and specific direction in regard to IDH. Additionally, they inferred that it is the invisibility of the asymptomatic episodes and the uncertainty of IDH definitions, which makes early IDH recognition and intervention so difficult. Furthermore, the unknown number of asymptomatic events might contribute to an underestimation of cases, which can have a negative impact on multiple organ systems. One might ask how renal nurses can better deal with an imperceptible event which can have such significant ramifications on the overall long term condition of their patients. The study by Bradshaw et al. (2015) provides valuable insights into the need for reliable and objective data for renal nurses to correctly assess patients even during their treatment. This should not only be limited to systolic and diastolic blood pressure, mean arterial pressure (MAP) and pulse pressure.

Daugirdas (2014) proposed measuring the frequency of IDH episodes to advance the quality of care. With this measure it is likely that nurses and other health professionals could become more aware of the existing problem of IDH and as a consequence, act more carefully or initiate quality improvement measurements. Sinha (2011) argued that assistive technology offers an option for improving the subjective clinical assessment for the definition of IBW, but cautions the need for well-designed and adequately powered clinical trials. Weiner et al. (2014) recommended clinical trials, to evaluate the impact of technologies determining volume status during haemodialysis on morbidity and mortality outcomes.

Existing preventative approaches vary from unit to unit with weight-based measurements and blood pressure recordings and BVM most common. In most recent years bioimpedance measurements e.g. Body Composition Monitor (BCM, Fresenius) have evolved to assist in some haemodialysis units to determine the patient's overall fluid status (Wabel et al., 2008). Whilst this tool gives an impression of total body water, it cannot discriminate between extravascular fluid and intravascular volume, whereas the critical determinant for the definition of an UF goal is the intravascular fluid status (Jaeger and Mehta, 1999). Caution has been suggested in using this tool as again too aggressive reduction of IBW without knowledge of the intravascular status could cause an untimely loss of residual urine output function (Davenport, 2013).

In a healthy person, 84% of blood volume is found within the systemic circulation and 64% of blood in the systemic circulation is pooled in the venous system, although this ratio does vary with different

states of venoconstriction and dilation (Hall et al., 2011). This indicates the importance of the venous blood system to the assessment of the intravascular volume status. The veins serve as a blood reservoir for circulation (Hall et al., 2011) and the inferior vena cava (IVC) represents the largest venous vessel in the human body. It is unsurprising that clinicians have chosen this particular vessel for volume assessment, assuming its collapsed or distended state reflects venous filling.

Brennan et al. (2006) demonstrated that the ultrasound (US) assessment of the IVC could be useful for evaluating the volume-status of a haemodialysis patient. Their study also revealed that medical residents with minimal echocardiographic training could measure the IVC with a portable ultrasound device. Their achievement in providing high-quality pictures was only slightly lower (89%), when compared to competent sonographers (94%) who used full echocardiographic platforms in previous studies. Brennan et al. (2006) also showed that almost 50% of their patients were volume depleted at the start of their dialysis session and concluded that IVC-US is an achievable option for swiftly assessing the intravascular volume status in a renal outpatient clinic setting. IVC diameter (IVCd) is successfully measured with IVC-US in emergency departments worldwide to assess circulating blood volume non-invasively. It is a reliable indicator of blood loss, even for small volumes (e.g. 450ml) (Lyon et al., 2005) and it has been suggested that it could be a useful tool for assessing potential volume-depleted patients. Md Noor and Mohd Salleh (2012) demonstrated that junior doctors were able to perform satisfactorily ultrasound measurements with a higher level of confidence after a basic 5-hour theoretical and practical training.

The diameter of the IVC varies through the respiratory cycle; therefore, it is necessary to obtain a US measurement of the IVC during inspiration (IVC minimum diameter = IVC_{min}) and a second on expiration (IVC maximum diameter = IVC_{max}). The IVC collapsibility index (IVCCI) is calculated from these two measurements and shows a correlation to the central venous pressure (CVP) (Thanakitcharu et al., 2013). Measurements of the IVCCI have been used successfully by Guiotto et al. (2010) to monitor intravascular volume status during slow continuous ultrafiltration in an ICU (intensive care unit). Additionally, it was found to be a simple and rapid method to monitor the intravascular volume status (Guiotto et al., 2010). A high degree of interrater reliability between emergency physicians when measuring the IVC with ultrasound has been demonstrated by (Fields et al., 2011).They concluded that visual estimation of IVC collapse had lower, but still moderate to good reliability. Sönmez et al. (1996) also identified IVC-US as a potential novel non-invasive method for estimation of ideal body weight (IBW) in children on haemodialysis. Hypovolemia is described as an IVCCI greater than 50% (Coba et al., 2010) and can be therefore used as an indicator for the volume status. This indicates that IVC-US is a successful method for objectively assessing the intravascular volume status, and has the potential to be used by renal nurses.

Although intradialytic variation in BP towards hypotension, particularly a decreasing MAP (Bradshaw and Bennett, 2015) is the most common signal nurses recognise as a predictor for imminent IDH, it can fail to deliver a meaningful intervention. In the case of an asymptomatic IDH most nurses may not use any intervention, and both nurses and patients tacitly accept hypotension as an inconvenient side effect of the treatment. It is also possible that the nurses are not even aware of the potential damaging risk of IDH (Flythe and Brunelli, 2015), as these events are dealt with routinely. Commonly accepted guidelines are lacking and renal doctors are not always present for a clinical fluid status review or individual patient review. It is also unclear how accurate their fluid assessments are. This leaves each renal nurse as solely responsible, usually only able to validate the intended UF goal with colleagues, and patient. Adding another objective parameter to the volume assessment process

could allow for improved assessment of the intravascular volume status, to the benefit of the renal nurse and the patient. Including IVCd into the equation when assessing for volume status, and not just relying on blood pressure and weight-based measurements only, could provide renal nurses with one more objective clinical dimension.

Patients are still deteriorating during haemodialysis despite many technical improvements enabling a better understanding of their fluid status. Generally, renal nurses use objective measures like blood pressure and body weight (pre- and post-treatment) and their clinical observation skills to support their chosen UF goal. Presently, renal nurses have not been empowered to explore novel or different approaches to assess a patient's fluid status, yet they spend significant time with haemodialysis patients. What is clear is that each episode of IDH has a negative impact, not only on the cardiovascular system (McIntyre, 2010), but also on other organ systems like the brain and GIT (McIntyre and Goldsmith, 2015) and so should be avoided by all means.

As the sole operators of haemodialysis machines, renal nurses have the responsibility and obligation to make critical clinical decisions at the start of each treatment, when they enter the ultrafiltration goal into the haemodialysis machine. This moment can be crucial to the success of the treatment they deliver. Renal nurses play a key role for a smooth and clinically uneventful haemodialysis session. By utilizing diagnostic devices in the renal setting, a nurse has the potential to better monitor the patient's clinical status *during* the treatment. Renal nurses are clearly in need of more objective parameters to better understand their patient's volume status and to develop improved preventative strategies for IDH.

IMPLICATIONS FOR PRACTICE

- Renal nurses must be made aware and receive more specific education about the overall negative impact of each episode of IDH
- Opportunities for the prevention of IDH must receive more attention by the treating renal team
- Observed episodes of IDH, regardless of whether symptomatic or asymptomatic, need to be regularly documented by the treating nurses to emphasize the existence of these evidently harmful events
- Adding the objective parameter IVC-US to volume assessment could potentially lead to a better understanding when assessing for fluid status
- Visual estimation of IVC collapse with ultrasound could be considered when assessing for volume status
- Renal nurses could be empowered to learn the skill of using abdominal ultrasound of the inferior vena cava to utilise another objective parameter for intravascular volume assessment

CONCLUSION

A review of the literature has shown that ultrasound can be effective in recognizing volume related hypotension and that the skill, not the occupation of the operator, is the deciding factor. Nephrologists with only little ultrasound training could satisfactorily perform IVC-US and when compared to a cardiologist, reached excellent and substantial agreement between both specialists. IVC-US has

already been used successfully by nurses in a variety of clinical settings such as emergency departments and heart failure clinics, with results comparable to ultrasound experts. Furthermore, it has been posited that intradialytic ultrasound could be used to predict hypotension in dialysis patients with minimal side effects. Therefore, it is hypothesized that renal nurses are able to use IVC-US for volume assessment in outpatient haemodialysis clinics and, given adequate training, could potentially use ultrasound to diagnose imminent intradialytic hypotension and avoid adverse outcomes. IVC-US could monitor intravascular volume status directly at any time of dialysis and would be novel and unique. It could potentially add another important clinical dimension for volume assessment.

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