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Australian Vascular Access Society

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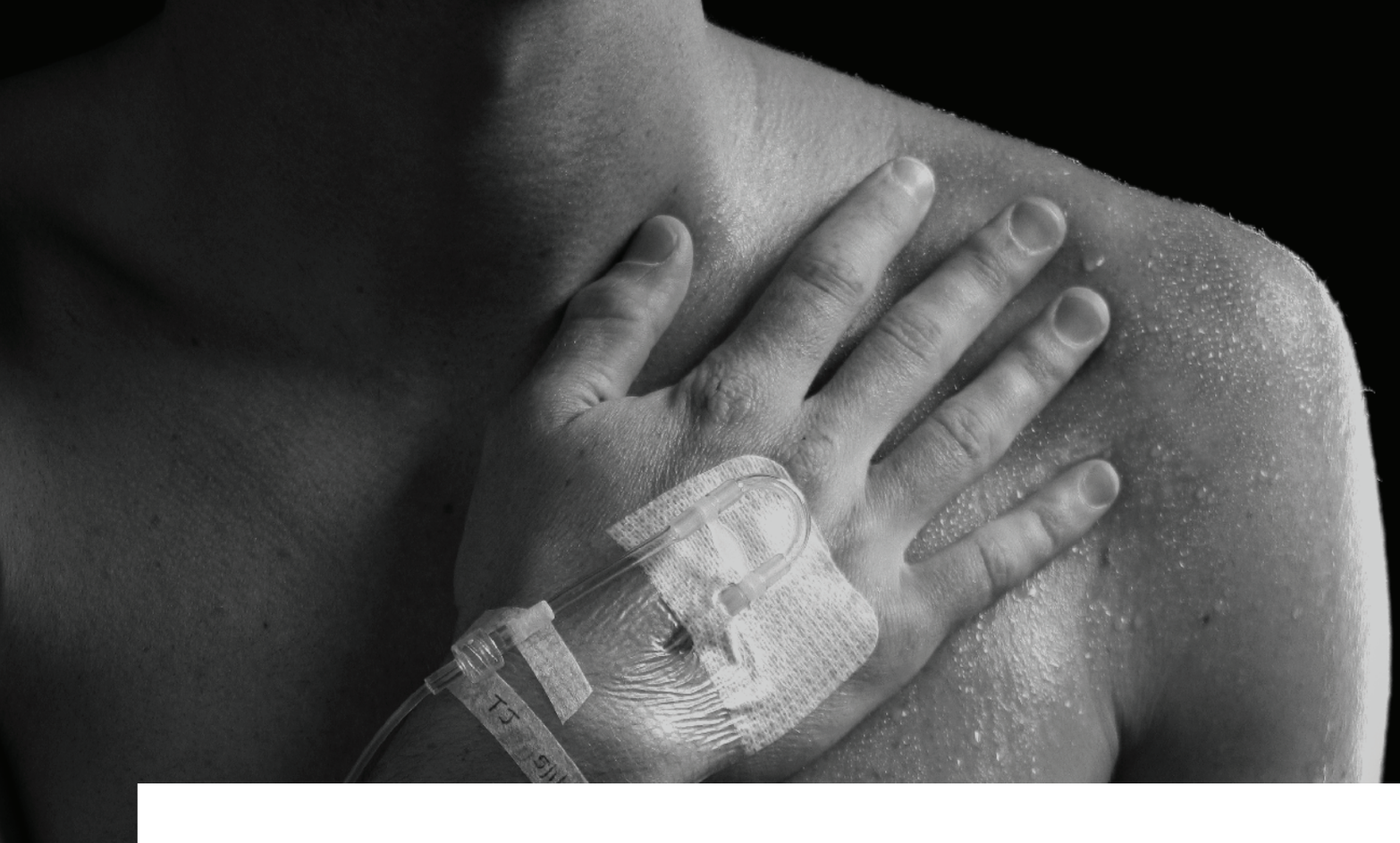

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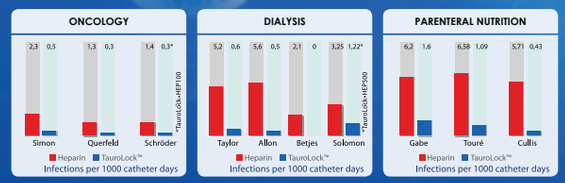

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* Punt, C.D., Boer, W.E. Cardiac arrest following injection of concentrated trisodium citrate, Clinical Nephrology, 2008, 69: 117-118. ** Willicombe, M.K., Vernon, K., Davenport, A. Embolic Complications From Central Venous Hemodialysis Catheters; Used With Hypertonic Citrate Locking Solutions. American Journal of Kidney Diseases, 2010, 55: pp 348 - 351. *** Polaschegg, H.-D., Sodemann, K. Risks related to catheter locking solutions containing concentrated citrate, Nephrol. Dial. Transplant. 2003, 18: 2688-2690. **** Schilcher, G. Polaschegg H.D. et al. Hypertonic Trisodium Citrate Induces Protein Precipitation in Hemodialysis Catheters, Selected ASN Meeting Abstracts, 2011

Guest Editorial

Welcome to AVAS

Tim Spencer RN, APN, DipAppSci, Bach.Health, ICCert, VA-BC
Founding President of AVAS (2009–2015)

Dear colleagues,

As the Australian Vascular Access Society (AVAS) begins its first official year, and as its founding president, I wish to welcome you on behalf of the Board and Executive members. Since its inception in 2009, AVAS has made steady progress in regard to its establishment as a professional body and organisation for clinicians working in or with vascular access and its associated devices.

AVAS has taken some time to establish a voluntary Board of Directors and State Executive, which culminated in the early development of societal by-laws and a binding legal constitution. In taking these steps, we have begun to establish the foundations of a solidly built professional organisation, along with the help of The Association Specialists, who have provided the society with full support and a framework structure to help build a robust and stable professional environment.

The AVAS mission is to promote and improve patient safety and clinical outcomes as well as develop a standard of excellence in the field of vascular access by promoting the development of national standards of practice, providing professional development and quality education, developing and sharing best practices and promote ongoing research within the vascular access realm.

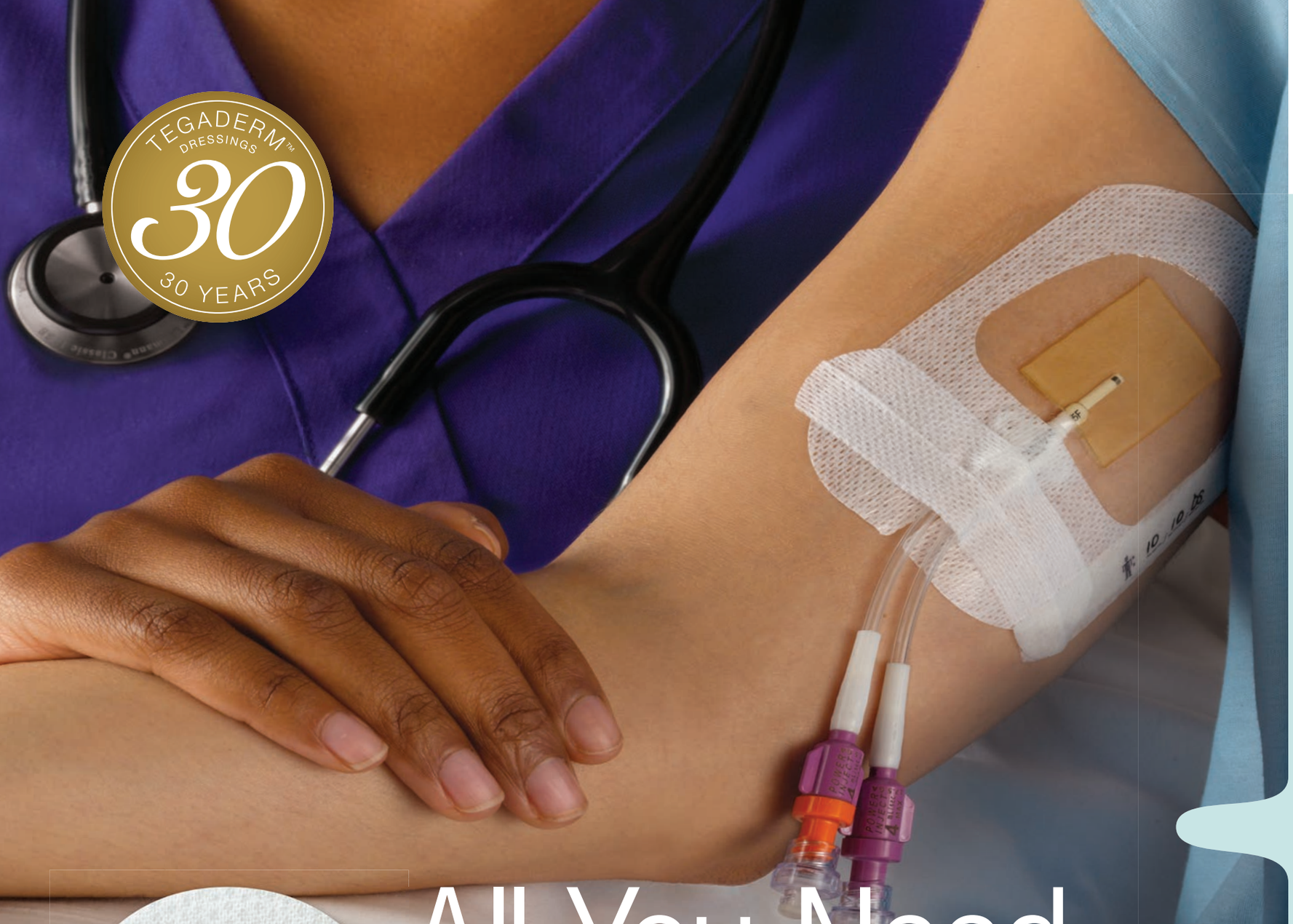
We are also pleased to announce the release of *VASCULAR ACCESS*, the peer-reviewed, multidisciplinary, official eJournal of AVAS. *VASCULAR ACCESS* accepts original articles from authors across a wide-ranging field and utilises the latest app technology to present everything relating to vascular access in the most modern and dynamic platform available. The eJournal is available in popular platforms for Apple™, Android™ and PC/Mac configurations.

AVAS also has an affiliation with the *European Journal of Vascular Access (JVA)*, in the form of its digital online access to all AVAS members. *JVA* has become the most authoritative journal in the field of vascular access and dialysis, thanks to the outstanding editorship of Dr Maurizio Gallieni and to the numerous European and American scientific societies that are affiliated. We look forward to the collaboration between JVA and AVAS to make membership more interesting for our AVAS members.

As we enter the first half of 2015 and our first AGM and educational offering, I would like to thank our AVAS Board and Executive, respective committee members, as well as The Association Specialists and Cambridge Media for their ongoing help and assistance in helping establish AVAS as the leading society in vascular access. It has been a long road, but the benefits are now starting to show.

As the outgoing president, I wish the incoming president Samantha Keogh, and the new Board members all the best in their roles and look forward to working with the Board, the Executive, and with you, our members, to strengthen AVAS to make this a productive and stimulating professional organisation for vascular access science.

Tim Spencer



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President Welcome

Samantha Keogh
Incoming AVAS President

Welcome to the first edition of the Australian Vascular Access Society's peer-reviewed journal. The journal, and indeed the society, is the culmination of the efforts of a committed group over recent years, as outlined in the editorial written by founding president Tim Spencer.

The society held its first annual general meeting (AGM) in Sydney CBD on 21 March 2015, along with an afternoon symposium consisting of presentations of exiting vascular access research and practice in Australia. The newly installed executive and I are pleased and proud to lead AVAS over the next two years. In addition to carrying on the good work of the founding committee, our key aims are to grow the membership and plan the society's inaugural annual scientific meeting. The meeting will showcase some of Australia's innovative vascular access research, education and practice, plus high-profile international guests and industry partners. The meeting is provisionally scheduled for some time in late April/early May in Brisbane. Watch this space for the date claimer and more details.

In the meantime, please enjoy this first edition of *AVAS Journal* with insightful and scholarly contributions that are but a small taste of the exceptional and exciting work being done by those working across the multitude of settings with patients requiring vascular access to deliver essential health care today.

Best wishes,

Samantha Keogh

The role of the vascular access nurse practitioner in developing evidence, promoting evidence-based vascular access practice and improving health services

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ABSTRACT

Complications and failure of intravascular devices place significant burden on nursing workloads, patient outcomes and the health care system. The development and implementation of evidence to improve clinical practice surrounding the insertion and management of intravascular devices is an ongoing challenge to which nurse practitioners (NPs) in vascular access can respond.

NPs use their clinical expertise to lead practice, facilitate change and monitor effectiveness of interventions to prevent complications. This places NPs in an ideal position to incorporate research into practice and lead the development of new research. But the demands and recency of the role means that NPs frequently find themselves inadequately prepared to lead the development and implementation of new research.

Collaborative relationships between NPs and academic researchers, scientific and clinical staff are necessary to promote effective and efficient health services, research and nursing practice. This is especially evident within the field of vascular access. Together, such collaborations are able to create and share knowledge that has meaning for the practitioners, to optimise the NP's role, and provide a bridge to overcome gaps in knowledge translation and evidence implementation.

This paper aims to explore the research aspects of the vascular access NP role within the context of multidisciplinary health research collaborations. It uses a case study of an NP involved in a health research collaboration within the vascular access specialty to illustrate this development, and further describes the potential impact of NPs upon evidence-based practice development.

INTRODUCTION

The majority of patients who are admitted to hospitals require the insertion of an intravascular device (IVD)[1-3]. They permit the infusion of medicines into the blood circulatory system, a means to sample blood for diagnostic purposes and the application of invasive haemodynamic monitoring[4]. IVDs are used across all medical, surgical, palliative and critical care specialties and from hospital to home environments.

Despite their necessity and ubiquity, the insertion, ownership and management of IVDs is frequently haphazard and the devices are prone to failure[5]. IVD failure prior to the end of therapy is commonly reported in 20–50% of peripheral, central and peripherally inserted central venous devices[5-7]. The insertion and management of IVDs needs to be based upon existing rigorous evidence that can reduce preventable failure as well as ongoing new research to improve the insertion experience. The multidimensionality and complexity of vascular access, and the variety of patients and health care providers involved in their care provides further challenges to the development and implementation of evidence-based practice in this field.

While advanced practice nursing roles in vascular access exist and contribute to excellence in some health services in Australia[8], these roles (for example, clinical nurse consultants) are not regulated in the same way as nurse practitioners (NPs). Since

their introduction, NPs have become leaders and innovators in clinical practice, especially within the field of vascular access. Internationally, the NP role was developed as an advanced practice nursing responsibility, with high levels of autonomy, collaboration and a broadened scope of practice compared to other registered nurses[9,10]. Like other advanced practice nursing roles, NPs are embedded in the health care system and are highly respected by other clinical staff members due to their credibility as local leaders in their specialty area of service provision. NPs use their clinical expertise to lead practice, facilitate change and monitor effectiveness of interventions to prevent complications[11], which places NPs in an ideal position to incorporate research into practice through the integration of existing evidence and the development of new evidence[9]. All NPs have some level of research education and experience, as this is typically required for registration. However, NPs may not have adequate research knowledge and skills to independently critique or synthesise evidence or to design and lead research studies. Research has focused on the NP as the participant — rather than the investigator[10,12,13]. The role of NPs as research initiators, collaborators and advocates has not been adequately explored.

Collaborative relationships between academic, scientific and clinical staff are necessary to promote effective and efficient health-services research and interdisciplinary practice, within and outside of vascular access[14,15]. However, the mechanisms for enhancing clinical and academic collaborative relationships, such as joint clinical-academic appointments, rarely exist in health care. Hospitals and universities/research institutes focus principally in concordance with their immediate priorities, that is, clinical throughput and teaching/research respectively. This can contribute to the 'evidence-practice' gap, which continues to restrain health care from achieving its optimal efficiency and patient outcomes.

This paper aims to explore the role of NPs within multidisciplinary health research collaborations, to improve vascular access practice. It uses a case study of an NP in Australia involved in a health research collaboration within vascular access to illustrate this development, and further describes the potential impact of NPs upon evidence-based practice development.

RESEARCH AND EVIDENCE-BASED PRACTICE IMPLEMENTATION

Evidence-based vascular access practice requires an interdisciplinary, bench-to-bedside approach. Throughout health care the implementation of evidence-based practice at the bedside is a continuing struggle, with many authors lamenting the challenges associated with replacing traditional nursing habits with evidence-based practice[16-19]. The Cooksey Report[20] from the United Kingdom (UK) distinguishes the varied layers of impediments to evidence-based practice implementation, highlighting the need for strategies which focus on both the first (scientist's bench to product/process/service) and second gaps (their routine use in practice). The McKeon Report[21] from Australia is similarly disparaging of the 'separation' of research functions from the hospitals and suggests greater integration of academic health centres. For effective implementation of evidence into practice to be achieved, systems that widely disseminate innovations need to be established and health care staff need to be skilled to critique, apply and evaluate evidence[22].

Several studies have demonstrated that clinicians' beliefs and attitudes about research are indicative of whether they will apply newly created evidence[23-25]. Clinicians across all health care disciplines also need to be engaged and participatory in the creation of the evidence in order to inform the generation of evidence across specific health disciplines[22]. To reduce barriers to health care research and evidence implementation, health care leaders have

supported the creation of an infrastructure to engage clinicians in evidence-based practice and the research process[26]. These infrastructure strategies have included journal clubs, evidence-based practice programmes, health care research councils, centres of research excellence, research symposiums, clinical research fellowships and professor-in-residence programmes[16,27-29]. While innovative, these strategies are rarely effective when adopted in isolation, and without investment and endorsement by locally respected clinical leaders[26,30].

Figure 1

UK Medical Research Council: Key elements of the development and evaluation process

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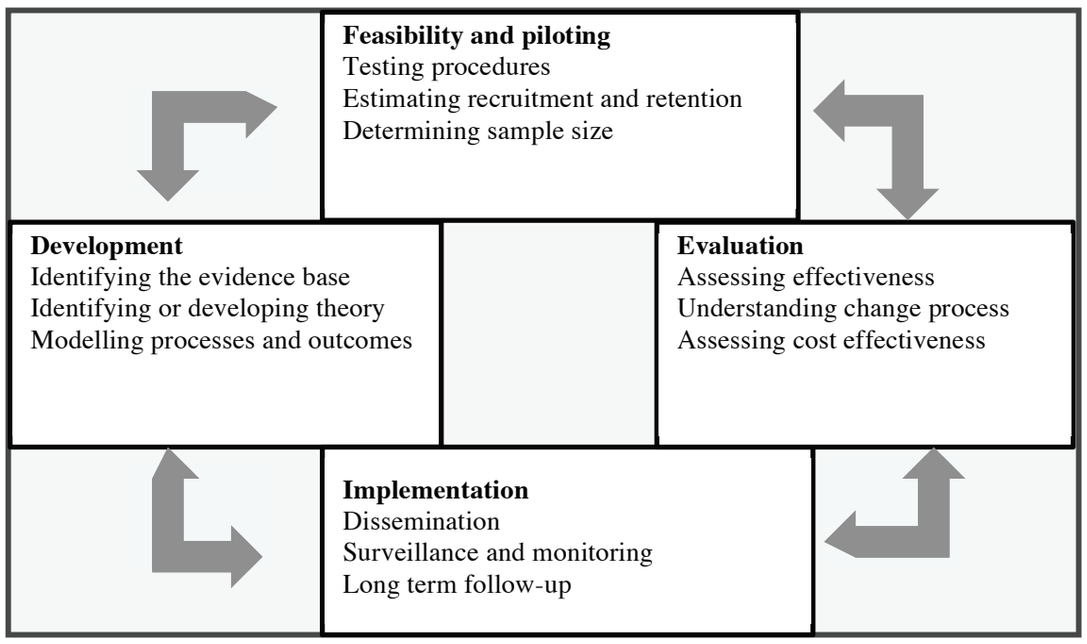

COLLABORATIVE RESEARCH GROUPS

Current nursing and health research groups have learned from past programmes where academic groups based in the university sector have undertaken research in isolation and then found their research outcomes were out-of-touch and unacceptable for clinicians[15]. The Australian Governments' National Health and Medical Research Council (NHMRC) Strategic Plan[31] includes a priority action to accelerate the research translation via collaboration between institutions towards research, translation, education and patient care. Both the NHMRC[31] and the UK Medical Research Council[32] highlight the need to plan implementation of research from the earliest inception of the research design, including involving future decision makers as an active strategy to progress evidence into practice. It is imperative that researchers consider end-users (for example, patients with an IVD and nurses who care for them) and the intricacies involved in implementing research into clinical practice from the outset of trial design. Research will have no impact if clinicians and health care policy makers ignore the results, and, conversely, if researchers do not understand why this occurs. A circular, integrative concept of health care research and implementation was illustrated by the UK Medical Research Council in 2005[33] (see Figure 1).

In response to these recommendations, research groups have developed collaborative partnerships between university-based academics and skilled clinical, scientific, administrative and educational staff. These partnerships share common purpose, goals, mutual respect, informed participation and shared decision making and often involve crossing the traditional discipline and sector silos[15]. They focus on the development, undertaking and implementation of research in a specific field, condition, topic or health care setting (for example, nursing, cystic fibrosis, vascular access, aged care).

Fostering partnerships between academics and clinical staff provides a means to develop and implement research programmes and outcomes. Communities of practice, such as clinical-academic research partnerships, provide a strategy to create and share knowledge which is meaningful for practitioners and increases the likelihood that research outcomes will be successful when implemented[14]. Each participant in the collaboration provides complementary strengths and capabilities to ensure a well-rounded approach to research development and implementation[30]. Health care systems are complex, and insufficiencies in health care delivery require the development of multilayered novel solutions[32]. An integrative, communicative, collaborative research group is required to find, develop and evaluate successful solutions.

THE ROLE OF NURSE PRACTITIONERS

The roles and responsibilities of NPs are expanding daily, with large representation practising within vascular access, predominantly within North America. NPs are now considered expert clinicians, educators, technicians, evidence-based practice advocates, opinion leaders and policy makers, capable of delivering high-quality, cost-effective care in a multitude of practice settings, including vascular access[9,13,34]. These high aspirations and expectations are supported by the outcomes achieved by this relatively new group of health professionals[35-39].

Advanced care nurses and NPs are distinctively positioned to identify gaps in current evidence, as substantiated through their daily practice[9]. These gaps can inform the development of integrated and clinically orientated research. Internationally, NP training involves the completion of tertiary studies at the Masters or Professional Doctorate level, in the academic sector in collaboration with clinical settings[40,41]. Frequently the tertiary study includes the completion of research-based content, including research methodology, critique of evidence and the interpretation of statistical analysis[42,43]. With the training NPs receive during their candidacy, NPs are able to combine their expert clinical knowledge with their research familiarity — using the resources that academic–clinical research collaborations have to offer. This allows them to contribute to the development, undertaking, evaluation and implementation of evidence for practice. NPs can provide an intellectual and logistical bridge between the academic and clinical health care domains, which has benefit for all health care providers and recipients.

NPs do not work in isolation within their clinical practice. They are a familiar and respected resource for the multilayered, interdisciplinary health care team, able to provide knowledge and skills during research projects and beyond. Their advanced verbal and written communication skills used in their clinical practice and service development are invaluable when undertaking collaborative research projects. The skills and multifaceted roles of NPs as expert clinicians, educators, technicians, opinion leaders and policy makers, make them ideal and invaluable research collaborators for academic staff.

NPs have the potential to benefit from the resources available to them within the academic–clinical research collaboration. Academic faculty and clinical staff who are part of the research collaboration become an additional network of support and mentorship for the NP. This includes the availability of faculty with high-level research skills, training opportunities, support for research funding, manuscript preparation and project management expertise. They may also provide access to specialist non-clinical researchers such as statisticians and health economists. The collaboration has the means to be beneficial to all parties; including the patients, family members and health care service.

CASE STUDY: AN AUSTRALIAN NP IN A VASCULAR ACCESS RESEARCH COLLABORATION

After an extensive career in paediatric vascular assessment, insertion and device management in the United Kingdom, and later Australia, Ms Tricia Kleidon became the first NP in vascular access and management in Australia in 2013 at the Royal Children's Hospital (RCH), Brisbane and since December 2014, the Lady Cilento Children's Hospital, Brisbane. Her professional career has been dedicated to the development and implementation of evidence-based practice in the multidisciplinary field of paediatric vascular access. Ms Kleidon structures her practices as an NP using the Strong Model of Advanced Practice[44]. Within this model, five domains are utilised to support the advanced nursing practice role: direct comprehensive care; support of systems; education; research publication; and professional leadership.

To inform and develop her role as an advanced practitioner, Ms Kleidon developed a research collaboration with the Alliance for Vascular Access Teaching and Research (AVATAR) group, led by Professor Claire Rickard from the NHMRC Centre of Research Excellence in Nursing, Griffith Health Institute. Since its launch in 2007, the AVATAR Group has developed to become a truly multidisciplinary, collaborative, clinical and academic, teaching and research group with representatives ranging from nurses and medical practitioners from many clinical specialties (for example, intensive care, anaesthetics, surgery, infectious diseases, paediatrics), microbiologists, researchers, health economists and statisticians. The AVATAR Group's goal is to develop evidence to ensure venous health and preservation through prevention of complications associated with intravascular access, using a multidimensional approach.

Ms Kleidon initially became involved in single-issue projects within the AVATAR Group, and is now a part-time research fellow within the research collaboration. Both the AVATAR Group and Ms Kleidon have benefited from the partnership, with a range of research projects developed, as seen in Table 1 (PULL OUT TAB ON LEFT TO SEE TABLE). In addition, Ms Kleidon provided content advice during the development of a postgraduate Master's subject on vascular access. The AVATAR group has utilised Ms Kleidon's expert and current clinical knowledge towards the development of research questions, informed research design and problem-solving practicalities regarding the projects' implementation. The AVATAR Group has also utilised Ms Kleidon's extensive network within the RCH to improve the feasibility of undertaking research, and to draw in other interested clinicians to work as research nurses, and to join the AVATAR Group. In reciprocation, Ms Kleidon has developed research skills including methodology, writing and project management under the tutelage of research leaders in the field of vascular access. The collaboration has resulted in mutual mentorship, with Ms Kleidon able to mentor researchers in advanced clinical expertise and skills. The health care staff, health care facility and patients at the RCH have benefited from the timely introduction of new vascular access evidence to the bedside. Both the RCH and Griffith University have benefited through the building of research and academic capacity through the mentorship of developing health care researchers.

The evidence-based care facilitation structure enabled by NPs is illustrated in Figure 2. It describes the people, benefits and outcomes that can be achieved by sharing the skills and knowledge available within the academic research group and health care institution domains.

IMPLICATIONS FOR HEALTH CARE AND ACADEMIC INSTITUTIONS

Barriers to clinicians' use of research and implementation of evidence are predominantly related to attitudes, challenges

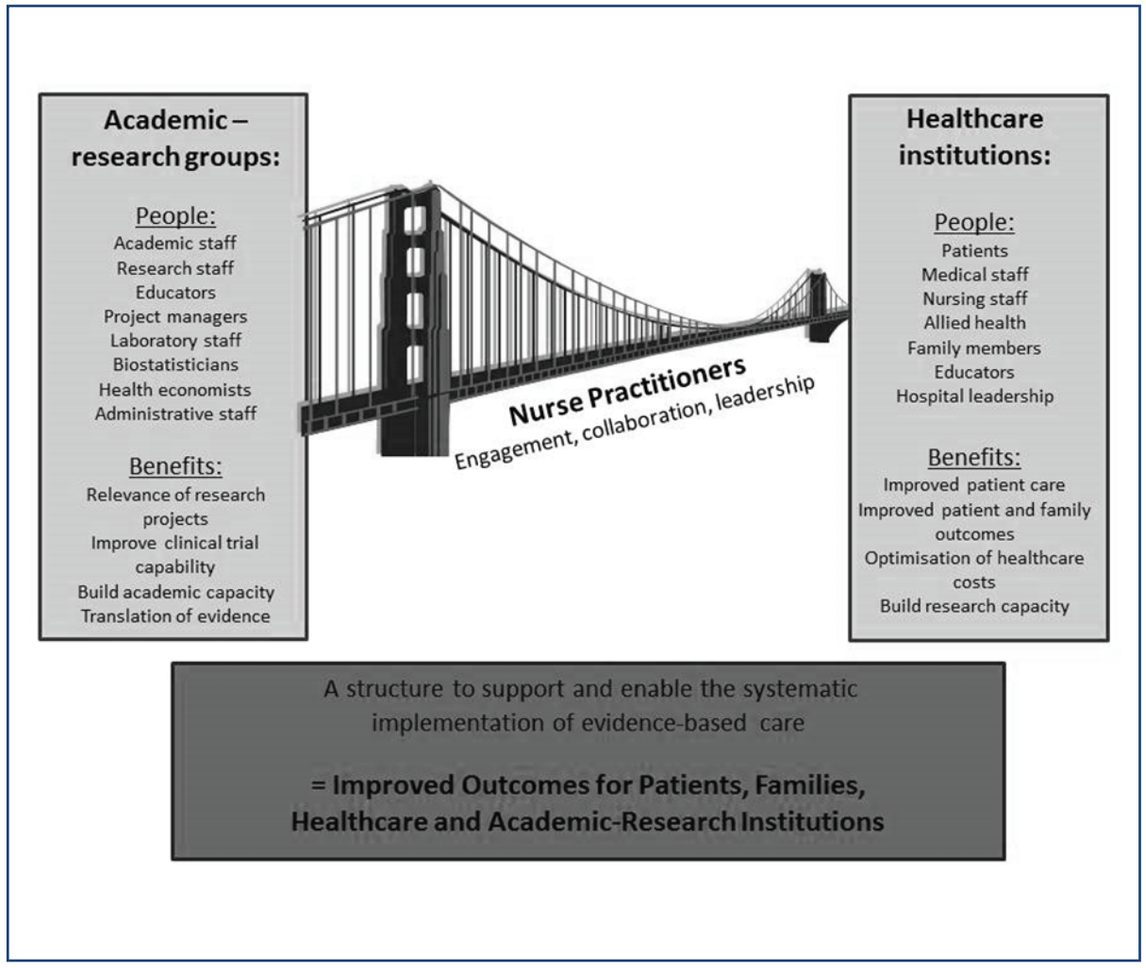

Figure 2

NPs as evidence-based care facilitators: an illustrative model

in effecting practice change, lack of knowledgeable mentors and insufficient resources (for example, time and personnel) to conduct research[26,45,46]. Within vascular access and beyond, academic–clinical research collaborations provide the necessary resources and skills that would otherwise make clinical research unachievable and the implementation of evidence impossible. Together these collaborations enable the creation and sharing of knowledge that is meaningful for the practitioners and can bridge the gap in translating knowledge and implementing evidence.

The mutual growth of research capacity has benefits for health care and academic institutions. The research will translate to improve patient care and outcomes and increase the skill set of both clinicians and academics[15]. Academic staff maintain their programme of research grounded in clinical practice, which is relevant to the bedside[15]. The implementation of evidence-based practice in the field of vascular access has the ability to save health care funds, through the reduction of preventable complications and wasted resources. A recent Australian example of research-based cost savings in vascular access includes the move from routine to clinically indicated replacement of peripheral IVDs. This is estimated to save A$7.60 per patient and approximately A$5 million over 5 years[47]. Further savings with the institution of future vascular access research is realistic.

The role of the NPs within these collaborations needs to be further explored and evaluated for effectiveness. Their involvement in research has the potential to drive sustained improvements in health care which are informed by clinical need and supported by the rigour of high-level research. A balance needs to be achieved so that NPs are not overwhelmed with the responsibilities of research to the detriment of their other roles and responsibilities as a clinician. However, the completion of direct patient care is not mutually exclusive from the other important domains of an advanced practice nurse, as some aspects of practice involve multiple characteristics of the roles demands.

Moving forward, NPs and academic health care staff need to seek opportunities to collaborate to ensure they optimise the creation and translation of evidence into clinical practice, especially within the field of vascular access. Together they have an opportunity to discover innovative, clinical- and cost-effective solutions and ensure their rapid and successful implementation at the bedside.

Conclusion

The prevention of complications associated with IVDs (for example, catheter-related bloodstream infection, occlusion and venous thrombosis) requires the development of rigorous evidence and the coordinated implementation of the outcomes of this research. This paper has outlined a model for the development and integration of vascular access research, which invigorates both NP roles and clinical-academic research groups based on collaboration, mutual respect and complementary knowledge and skills. As NP roles increasingly proliferate in the health care system, models such as these must become more visible and productive to progress consistent, evidence-based care, and clinically relevant, scientifically rigorous projects that have benefits to the community and the health sector.

Conflict of interests

The authors have received funding from government, university and commercial entities for their research unrelated to this paper. The authors declare that there are no conflicts of interests regarding the publication of this paper.

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TABLE 1

CASE STUDY: VASCULAR ACCESS RESEARCH PROJECTS DEVELOPED BETWEEN MS TRICIA KLEIDON (NP) AND THE AVATAR GROUP SINCE 2012

Project	NP Role
Central venous Access device SeCurement And Dressing Effectiveness: the CASCADE Trial	• Lead pilot feasibility trials in paediatrics • Associate investigator in national competitive grant funding applications • Chief investigator in industry linkage funding applications • Project management
FLushing in Peripheral intravenous catheters (FliP): A randomised trial of high versus low frequency.	• Leading pilot feasibility trials in paediatrics • Chief investigator in university funding applications
Peripherally Inserted Central Catheter OutcoMes: Polyurethane And silicone veRsus Endexo (PIC COMPARE)	• Chief investigator in a potential multisite, randomised control trial
Central venous access device management in tertiary paediatric care: a quasi-experimental study to evaluate a multidimensional intervention	• Chief investigator
How to make your peripheral intravenous catheter insertion a SUCCeSS: Implementation of a care bundle to improve intravenous catheter insertion practices in paediatrics	• Chief investigator in a national competitive funding application

NP = nurse practitioner

Assessment of dressing and securement techniques for peripheral arterial catheters: a narrative review

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ABSTRACT

Background: **Peripheral arterial catheters (AC) are widely used in critical care patients for continuous blood pressure monitoring and blood sampling, yet failure — from dislodgement, accidental removal, phlebitis, pain, occlusion or infection — is common. Effective methods of dressing and securement are needed to prevent complications that cause failure, yet few studies have been conducted that explore this problem.**

Aim: **To perform a narrative review of research literature about dressing and securement of ACs.**

Methods: **A literature search of the Cochrane Central Register of Controlled Trials, Ovid MEDLINE, Ovid EMBASE, and EBSCO CINAHL, as well as Google and Google Scholar was performed. A meta-analysis or systematic review was not possible because of scarce literature.**

Results: **Guidelines for dressing and securement of intravascular devices did not specifically address ACs. One large, non-randomised study compared "band aids" with a sutureless securement device, finding a significant reduction in catheter failure associated with the sutureless securement device. Other studies of polyurethane dressings versus sutureless securement devices only studied intravenous, not ACs. One small, pilot, randomised controlled trial (RCT) indicated feasibility of the use of tissue adhesive plus a polyurethane dressing for ACs.**

Conclusion: There is limited high-quality research literature about effective dressing and securement of ACs.

INTRODUCTION

Millions of patients worldwide need a peripheral arterial catheter (AC) as a vital component of their critical care management[1]. Peripheral ACs are routinely inserted into a peripheral artery and are used for continuous blood pressure (BP) monitoring[2] and frequent blood sampling for essential blood tests, including blood gas analysis[3]. Although necessary and beneficial, ACs are not without complications, which may be mechanical or infective[4,5]. Up to 25% of ACs fail prematurely during treatment because of accidental removal (with the associated risk of life-threatening haemorrhage), dislodgement, occlusion or infection[4,6], and these adverse events are often related to inadequate dressing and securement of the catheter to the skin. Bloodstream infections occur in these devices about as often as in central venous catheters (CVCs), with ACs an under-recognised cause of catheter-related blood stream infection (CRBSI)[7-9]. Annually, Australians need up to an estimated 200,000 ACs to provide routine, necessary care in the operating theatre (OT) and intensive care unit (ICU). International yearly usage of ACs is extensive, with up to eight million in the United States of America (USA), and 2.5 million in Europe[1,5]. Failure of an AC from complications requires the device to be removed and a new device inserted for continued treatment. Complications of ACs, as with all intravascular catheters, are associated with patient suffering, prolonged hospitalisation, more expensive health care costs and increased mortality/morbidity[10-13]. The substantial costs of catheter-related infections create an imperative for health care providers to improve patient outcomes and reduce health care expenses[14].

The failure incidence in peripheral ACs is not often reported in the literature, but in one of the few studies available, it was reported that 69% (40/58) of AC insertion-related incidents were related to inadequate securement, and 24% (60/249) of post-insertion AC use problems involved dislodgement or inadvertent removal[4]. Further, high rates of accidental removal of ACs have been described compared with CVCs in intensive care studies, with two to four times as many incidents reported[15,16]. Other literature acknowledges the serious risk of infection in peripheral ACs, and that this is commonly underestimated[7]. The incidence of AC-related infection in intensive care has been reported as 0.59 to 1.7 per 1,000 catheter days, with 0.3% to 0.8% of patients developing

a CRBSI[7,17]. A systematic review and meta-analysis confirmed that ACs have a substantial burden of CRBSI, with pooled incidence of CRBSI in ACs of 0.96 per 1,000 catheter days[8].

Two key factors in preventing AC complications are: (1) occlusive dressings — with the insertion site covered to prevent infection, and (2) effective securement — with ACs successfully secured to the skin to withstand external forces which may lead to dislodgement. For decades, the most common wound/insertion site dressing used for ACs have been simple polyurethane (SPU) — a small, transparent, rectangular film dressing with an adhesive layer. These dressings are inexpensive and popular, yet there is no evidence that they provide adequate securement rather than functioning merely as a wound dressing. They may not retain adhesion in patients who are diaphoretic or have AC insertion sites that are oozing, as seen in many ICU patients. In recent years, bordered polyurethane (BPU) dressings have emerged that are similar to SPU dressings, but with a toughened, adhesive fabric border. These dressings have not yet been rigorously and independently tested for use in ACs compared to SPUs. An independent, non-randomised study (n=407) in peripheral intravenous (IV) catheters (not ACs), reported less device failure with BPU dressings than with SPU, but this was not statistically significant (29% vs 19%, p=0.18)[18], and has limited generalisability to ACs.

AC securement has traditionally been via sutures, with an SPU dressing placed on top, paralleling a similar method of securement used for CVCs. This approach (sutures plus SPU) has been dominant since the 1980s, despite evidence of significantly increased bloodstream infections with sutures in peripherally inserted CVCs, and recommendations not to suture for CVCs by the American Centers for Disease Control (CDC)[13,19,20]. New alternatives for AC securement and dressings have become available that may be superior to sutures and SPU to prevent complications, but these have not yet been adequately tested for efficacy or cost-effectiveness. An option for ACs is to use a sutureless securement device (SSD), with strong adhesive pads that offer additional anchor points into which the AC can be "clipped" for securement, with an SPU still used as the wound covering. The CDC recommends the use of SSDs for CVCs to prevent vessel inflammation, catheter migration or dislodgement, and potentially CRBSIs, but there is no such recommendation for ACs[14]. The Infusion Nurses' Society Standards of Practice recommend SSDs for all intravascular catheters to maintain patency, minimise catheter movement at the hub, prevent dislodgement and to avoid suture-related complications of infection, pain, tissue trauma if the catheter is accidentally dislodged, as well as potential needlestick injuries[21]. In general, many intravascular catheter-related complications, either mechanical or infective, may be related to poor quality dressings and securement, with resultant catheter failure.

METHODS

The paucity of quality studies reporting efficacy of dressing and securement methods which may prevent complications and catheter failure in ACs, did not allow a meta-analysis or a systematic review. Thus, the available literature was critiqued using a narrative review. First, a literature search of the following electronic databases was made to identify reports of relevant randomised controlled trials (RCTs):

- The Cochrane Wounds Group Specialised Register; The Cochrane Central Register of Controlled Trials (CENTRAL) (2014)
- Ovid MEDLINE (1946 to present)
- Ovid EMBASE (1974 to present)
- EBSCO CINAHL (1982 to present).

The following search strategy was used in CENTRAL with MeSH descriptors: catheterisation, peripheral, peripheral arterial catheter, AC, occlusive dressings, securement device, StatLock®, tissue adhesive, skin glue, occlusive, gauze, tape, polyurethane, permeable, non-permeable, transparent, antimicrobial, anaesthesia, anesthesia, intensive care, ICU, Opsite®, Tegaderm™, Micropore™, and Hypafix®. The Ovid MEDLINE search was combined with the Cochrane Highly Sensitive Search Strategy for identifying randomised trials in MEDLINE, and the EMBASE search was combined with the Ovid EMBASE filter developed by the UK Cochrane Centre[22]. The following clinical trial registries were also searched:

- ClinicalTrials (http://www.clinicaltrials.gov/)
- WHO International Clinical Trials Registry Platform (http://apps.who.int/trialsearch/Default.aspx)
- EU Clinical Trials Register (https://www.clinicaltrialsregister.eu/).

This strategy was then adapted to search Ovid MEDLINE, Ovid EMBASE, EBSCO CINAHL, Google and Google Scholar for all studies and articles. The reference lists of all relevant publications which were retrieved were also searched for articles which had not been identified by the methods described above. Studies were not restricted with respect to language, or date of publication.

RESULTS

Guidelines for intravascular catheter dressings

Centers for Disease Control and Prevention: Guidelines for the Prevention of Intravascular Catheter-Related Infections

The CDC guidelines have no specific dressing recommendations for ACs, but advise either sterile gauze or a sterile, transparent, semi-permeable dressing to cover intravascular catheter sites, and SSDs to reduce the risk of catheter migration, colonisation and CRBSI, and needle stick injury[14]. Presumably, ACs fall under these broad recommendations, but specific guidance for these ACs would be preferable.

Australian Guidelines for the Prevention and Control of Infection in Healthcare

The National Guidelines[23] address health care-associated infections in relation to the management of intravascular catheters, as well as many other topics. They cite background information and recommendations extracted from the CDC guidelines, as well as from their own systematic review[24]. Catheter dressing regimens are specified as the use of either sterile gauze or sterile, transparent and semi-permeable dressings to cover intravascular catheter sites, with no specific protocols recommended for ACs.

Infusion Nurses' Society Standards of Practice

The Infusion Nurses' Society (INS) *Standards of Practice* Standard 44 specifies dressings for generic intravascular catheters, with advice for application of a sterile dressing that should be changed at established intervals, and immediately if integrity becomes compromised. Specified dressing choices include the transparent SPU dressing or gauze. It is recommended that the SPU dressing is changed every seven days, and gauze every 48 hours[25].

Standard 36 focuses on the importance of stabilisation for all intravascular catheters, and the latest recommendations include the routine use of stabilisation devices, and these may be interpreted as SSDs, although this is not specified[26]:

> *Standard 36.1* states that stabilisation should be used to preserve the integrity of the catheter, to minimise catheter movement at the hub, and prevent catheter dislodgement and loss of access.

Standard 36.2 states that intravascular catheters should be stabilised using a method that does not interfere with assessment and monitoring of the access site or impede vascular circulation or delivery of the prescribed therapy.

Standard 36.3 recommends that stabilisation methods be used that are established in organisational policies, procedures, and/or practice guidelines.

Standard 36.4 states that the nurse be competent in the proper use and application of stabilisation methods and devices.

Clinical practice criteria are also discussed in this Standard. The use of a stabilisation device is suggested as the preferred alternative to tape or sutures. The Standard states there is insufficient evidence to support the use of transparent SPU dressings for stabilisation at the IV catheter hub alone[26].

Primary research studies on dressing and securement of ACs

Standard polyurethane, bordered polyurethane dressings and securement-dressings

SPU and BPU dressings are also referred to as transparent, polyurethane, semi-permeable, window (BPU), and/or film dressings, as previously described, and are used to cover the catheter insertion site. BPU dressings are essentially an SPU dressing with a reinforced, opaque border with extra adhesive strips to secure the hub and tubing. Securement-dressings (S-Ds) are window-type BPUs with an extremely adhesive section and a second dressing placed over the first. Research about SPU dressings is first presented, followed by studies of BPU dressings and S-Ds. Product names of dressings are provided as named in the individual studies.

The most commonly used SPU dressings used since the 1980s have been Opsite®, Opsite® IV3000® [27] and Tegaderm™ [28]. It is notable that the manufacturers' product information states SPU dressings are not specifically designed to prevent catheter dislodgement, with their indications to cover and protect the insertion site, rather than provide catheter fixation. This does not appear to be understood clinically, with SPUs often used as the sole product both for dressing and securement. Opsite® is marketed for the management of superficial wounds such as shallow pressure sores, minor burns, cuts and abrasions, for use as a secondary dressing, and also specifically with Opsite® IV3000® to provide catheter fixation. Tegaderm™ package information describes it as indicated to protect IV sites, enhance wound healing, prevent skin breakdown, and to protect clean, closed surgical incisions[27,28].

Tegaderm™ is indicated for use to retain peripheral and central IV catheters only, but not to retain ACs, according to product testing guidelines as set out in the Surgical Materials Testing Laboratory (SMTL) Datacard for Tegaderm™ [29]. The SMTL Dressings Datacard website is part of the Welsh National Health Service, and is dedicated to providing a repository of independently authored datacards and test reports on surgical dressings and bandages[30]. Each datacard is written by an experienced author in the field, and submission requires peer-reviewed papers, technical product information and product samples. It is unclear why SPU dressings were marked as unsuitable for ACs. This statement was not referenced with clinical evidence. Details of authorship were not disclosed, so the author was not able to be contacted. Anecdotally in clinical practice, SPUs are often used for ACs.

Historically, SPU dressings have been applied to both AC and CVC insertion sites after the catheter has been sutured in place[31]. Suturing is now considered to contribute to CRBSI risk[14,32]. The literature provides evidence in peripherally inserted central

catheters (PICCs)[32], and the CDC guidelines reflect this change in perspective[14], with advice to use an SSD in preference to sutures, for intravascular catheters generically.

SPU dressings differ with respect to size, permeability and weight[33]. There may be corresponding clinical advantages in these variations, such as increased durability, improved catheter security, visibility of the wound or catheter site, and a better barrier to microorganisms. The manufacturers suggest these dressings provide infection protection by preventing the passage of liquids, bacteria and viruses through the dressing, while allowing water vapour, oxygen, and carbon dioxide to be exchanged with the surrounding air. This is measurable as the moisture vapour transmission rate to assess water vapour diffusion. However, no optimal transmission rate has been provided by clinical evidence[28]. There is better patient comfort if the dressing conforms to body contours, stretches easily, and prevents skin stress with patient movement. Tegaderm™ dressings are radiologically transparent, with a hypoallergenic, latex-free, acrylic adhesive, designed to be gentle when applied to the skin. Complete visibility of the site is provided by SPUs, allowing monitoring for signs of infection, leakage or catheter dislodgement[28]. SPUs may be worn for longer than tape and gauze[14], which enhances their affordability, with possible savings in nursing time and supply costs for dressing changes.

Large studies of SPU dressings are restricted to IV, not AC use. IV catheter data is somewhat, but not completely generalisable to ACs. Many manufacturers launched second-generation SPU dressings in the late 1980s and the 1990s, which claimed to have higher permeability to water vapour and various gases. This may increase the rate of evaporation at the catheter site, with the possibility of decreasing infection risk[34,35]. Maki and Ringer[35] found in their RCT of 2,088 peripheral IV catheters that moisture under the dressing was a significant risk factor for infection with a relative risk of 2.48 with older style SPU dressings. There have been no RCTs or other studies comparing the older and newer SPUs in ACs.

BPU dressings entered the marketplace in the 2000s with their transparent windows. With the strong, opaque adhesive described as retaining the advantage of a visible insertion site, while better securing the catheter, these dressings intended to avoid loosening and catheter movement[36]. BPU dressings meet USA industry definitions of a catheter securement device, rather than simply a wound dressing. Such BPU dressings have been developed by 3M™ [28] and Smith & Nephew[27], among others. The BPU dressing of Tegaderm™ I.V. Advanced Securement Dressing[37] and other similar dressings are increasingly used by those who believe they minimise the risks and pain of catheter movement and dislodgement. According to product information, Tegaderm™ I.V. Advanced Securement Dressings are intended to provide increased securement in short-term CVCs and ACs. The patterned film adhesives of these dressings hold strongly, and form a seal around the catheter site when applied with firm pressure. Additional sterile tape strips are precut for anchoring hubs, lumens or tubing to enhance stabilisation, and allow the dressing to withstand additional pull force. Tegaderm™ I.V. Advanced Securement Dressings plus tape strips are stated by the manufacturer to withstand twice the pull force of an SPU dressing[37]. As with SPU, this transparent film is said to allow effective oxygen-vapour exchange, while assisting in protection from external contaminants like bacteria and viruses infiltrating the catheter wound and contributing to CRBSIs.

There are only a few studies that have investigated the clinical use of BPU dressings or a related new class of S-Ds, notably the SorbaView SHIELD[18,38,39]. Callaghan *et al.*[18] performed a non-randomised trial of 407 IV catheters in paediatric patients, and

compared Tegaderm™ BPU dressings against tape used alone. The trial was independent of manufacturer sponsorship. Complications of dislodgement, insecure dressings, signs of phlebitis, and/or extravasations occurred in 41/212 (19%) catheters in the tape group, and at a significantly higher rate of 56/195 (29%) in the BPU group, p=0.018. Penney-Timmons[38] observed phlebitis and infiltration in relation to health care costs in 1,345 IV catheters, following introduction of an insertion kit[40], which contained a SorbaView® SHIELD S-D, against standard care of no kit and SPU plus tape. The study was independent of manufacturer sponsorship. Over a six-month period, phlebitis and infiltration incidence associated with the use of the insertion kit and SorbaView® dressing were zero — with cost savings of US$188,640 in a 700-bed facility. A major limitation is that no "pre-data" were provided on earlier complication incidence for comparison and understanding of cost calculations. Limitations of both studies were non-randomised designs, no sample size calculations, no blinding, and lack of reporting detail. Thus, they only provided weak evidence to support BPU use, especially as neither trial included ACs.

Flippo and Lee[39] also evaluated the SorbaView® SHIELD[41] BPU dressing in IV catheters, conducted over three phases. The catheter failure rate was 8/94 (9%) and 86% of nurses rated the overall performance of the SorbaView® SHIELD as good to excellent in 86% of cases. There were several limitations, with no control group, underpowered sample size, and no statistical comparisons. There was also a possibility of manufacturer bias, with the study materials and in-service training provided by the manufacturer. Overall, clinical studies to date have provided only limited and weak evidence regarding the effectiveness of BPU or securement dressings, but they do suggest a potential benefit that needs to be further investigated in ACs.

The properties of BPU have been compared with SPU and other securement methods in the laboratory setting, measuring the amount of force required to remove a peripheral IV catheter, which is technically the same catheter which may be used as an AC, in preference to a custom-made AC. The dressings and securements were compared in an *in vitro* comparative study. Mechanical tests compared securement options on porcine skin and showed that neither SPU nor BPU dressings significantly increased the pull-out force, compared with control catheters that had no dressing at all ($p>0.05$)[42]. This demonstrated that BPU, as well as SPU, did not significantly contribute to enhanced securement in the *in vitro* model. This may not translate to human tissue in the clinical setting, but it raises a concern, particularly in addition to the limited clinical evidence regarding the efficacy of BPU dressings.

Sutureless securement devices in peripheral ACs

SSDs came into being in the 1990s. They anchor intravascular catheter hubs to the skin to provide suture-free securement, and are used with an SPU that covers the catheter insertion site. SSDs have an adhesive anchoring pad holding the catheter in place. These devices are designed to improve patient comfort and safety and are intended to minimise complications in different catheter types, in particular ACs. There is importantly a secondary benefit in the elimination of needle stick injury risk by avoiding sutures. The StatLock® Select Arterial Stabilization Device[43] — and other SSDs that have now entered the market, such as Grip-Lok®[44], NovaCath™[45] and SecurAcath[46] — meet USA guidelines for sutureless securement as defined by the FDA. They are now recommended in both the INS and CDC guidelines[14,26,47]. However, the majority of research studies to date have been performed with the StatLock® device.

There is only one study that has tested the effectiveness of SSD use in ACs compared with other dressings and securement to prevent complications causing failure[6]. This large, non-randomised trial studied compared SSD to AC securement with two "band aids" plus

non-sterile tape (controls). Comparison of the clinical effect and cost benefit was made with 468 catheters secured with Tegaderm™ and the StatLock® Arterial Select device as the experimental group. There was an AC failure rate of 60/468 (12.8%) in the StatLock® group, compared with 253/995 (25%) failure in controls, which was statistically significant, p<0.001. This represented a 48.8% relative reduction in AC failure with the StatLock® device. The SSD cost more to purchase, but its use was cost-neutral in view of reduced complications[6]. It was an independent study powered to test the primary hypothesis, but had the limitations of a non-randomised design and inequality of group sizes. Further study using an RCT design is needed.

The landmark study by Yamamato e*t al.*[32] in PICCs, as referenced in the CDC guidelines[14,48], is often cited in peer-reviewed journals. It provides strong evidence of an RCT to support the use of the StatLock® SSD in place of sutures in intravascular catheters to prevent infection, as recommended in the CDC Guidelines, but not specifically in ACs[32].

Use of tissue adhesive for catheter securement

Limited clinical use of cyanoacrylate tissue adhesive (TA) to secure invasive catheters has been reported in the literature, with the initial uses reported with catheters other than ACs. The first use for securing any type of catheter in human participants was reported in the USA in 2004, to prevent displacement of epidural catheters during labour[49]. A drop of the TA, n-butyl-2-cyanoacrylate, was placed at the catheter insertion sites of seven patients' lumbar epidural catheters. The anaesthetists performing the study considered the "skin glue" would be beneficial to prevent displacement. They thought this would restrict catheter migration, and therefore limit the catheter failure rate. In this case series, six out of seven catheters showed no movement, and no complications were reported. The seventh catheter was dislodged. Limitations of this study were no control, small sample size, lack of randomisation, and no statistical analysis. Effective securement of CVCs and further use in epidural catheters has been achieved in a limited capacity using the TA Histoacryl® in adults. A small number of case studies and case series have shown TA to prevent accidental dislodgement of epidural catheters, as well CVCs[50-53].

A recent pilot randomised controlled trial of novel dressing and securement technologies for AC dressing and securement was performed to provide baseline estimates of effect as well as assess the feasibility of further study[54]. This four-arm, parallel, randomised, controlled, non-blinded pilot trial with 195 short-term intensive care patients investigated BPU, SSD and TA (experimental groups) compared with an SPU control group. AC failure was significantly worse with SPU dressings (10/47 [21%]) than with BPU dressings (2/43 [5%]; p = 0.03), but not significantly different to TA (6/56 [11%]); p = 0.18) or SSD (8/49 [16%]; p = 0.61). The newer technologies were all found to be feasible options, with further study of the interventions recommended. Most recently, a pilot RCT in the operating theatre and intensive care[55] tested one dressing (BPU) and two securement methods (StatLock® SSD and Histoacryl® TA) versus usual care SPU in 123 patients. The primary outcome of catheter failure was 2/32 (6.3%) for TA, 4/30 (13.3%) for BPU and 6/30 (20%) for the SSD. Cost analysis suggested that tissue adhesive was the most cost effective. Therefore, use of TA to secure ACs has been shown to be a potentially effective method, but requires further study.

CONCLUSION

Millions of patients in the operating theatre and the intensive care unit are at risk of having peripheral ACs inadvertently dislodged, or suffering other mechanical or infective complications which result in catheter failure. These complications can be critical, with

the potential for life threatening outcomes including haemorrhage following inadvertent removal, and CRBSI. There are few studies in ACs about complications leading to catheter failure in ACs which may be prevented by improved dressing and securement. Research continues to be conducted about the incidence and outcomes of CRBSI in ACs, however, these studies often make comparisons of incidence with other intravascular catheters. Only two pilot AC studies have investigated SPU/BPU dressings and SSDs, to demonstrate their feasibility for future research[54,55]. The one large non-randomised study of dressing and securement of ACs focused on SSDs, and showed a significant reduction in AC failure[6]. The use of TA to perform securement for intravascular catheters is a new concept, and has shown preliminary effectiveness in securing ACs in two pilot trials[54,55]. It is notable that this review found no reports of problems (potential of actual) with the dressing and securement methods in any of the studies. In summary, a review of the literature has shown only a few studies that have investigated the many available dressing and securement methods and their relationship with AC failure. This literature gap presents a crucial area for future large-scale randomised controlled studies to establish a strong evidence base for dressing and securement of ACs.

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Percutaneous transluminal angioplasty for central venous disease in dialysis patients: influence on cardiac function

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ABSTRACT

Purpose: **Increased vascular access flow after percutaneous transluminal angioplasty (PTA) for central venous stenosis and occlusion (central venous disease, CVD) can affect cardiac function in hemodialysis (HD) patients. We evaluated the cardiac function, etiology, and treatment in HD patients with CVD.**

Methods: **HD patients with CVD treated by PTA between June 2006 and February 2013 were studied.**

Results: **Of the 26 patients, 22 had left arteriovenous fistulas (AVFs), 1 left arteriovenous graft (AVG), 2 right AVFs, and 1 right AVG. CVD sites were the left brachiocephalic vein (LBCV; n=13), left subclavian vein (LSCV; n=7), both LBCV and LSCV (n=3), right BCV (n=2), and right SCV (n=1). Computed tomography findings indicated a high extrinsic compression rate for the LBCV (91%) and LSCV (50%).**

The success rate of PTA was 96%. The primary patency rates at 3, 6, 9, and 12 months were 81%, 73%, 65%, and 57%, respectively. The post-PTA brachial artery flow volume was significantly increased compared with the pre-PTA volume (1306 vs. 957 ml/min; p=0.005). The post-PTA left ventricular ejection fraction and expiration inferior vena cava diameter were the same as the pre-PTA values (57% versus 60%, p=0.2 and 17 versus 17 mm, p=0.9, respectively).

Conclusions: **Our findings suggest that increased vascular access flow after PTA for CVD has no relation to cardiac function.**

INTRODUCTION

Central venous stenosis and occlusion (central venous disease, CVD) are common and serious complications of vascular access in hemodialysis (HD) patients and caused by the previous placement of central venous catheters (CVCs) (1, 2) or pacemaker wires (3, 4), extrinsic compression (5-7), or high flow and turbulent status resulting from the creation of an arteriovenous fistula (AVF) (8-10). CVD can result in swelling, pain, or the development of collateral veins and disrupts the HD access circuit by causing increased venous counter pressure at dialysis and access flow dysfunction (11-13). In these cases, percutaneous transluminal angioplasty (PTA) must be the primary treatment.

Cardiac mortality and morbidity rates have been demonstrated to be highly elevated in HD patients compared with those in healthy individuals (14). Several reports indicate that the HD procedure is associated with the development of regional left ventricular systolic dysfunction (15, 16) and sudden cardiac death (17). The flow of AVFs affects cardiac function (18). Moreover, high-flow AVFs are associated with an increased risk of cardiac failure (19). However, the associations between cardiac function and increased vascular access flow after PTA for CVD remain unclear.

In this study, we evaluated the influence of PTA on cardiac function as well as the etiology, treatment, and outcome of CVD in HD patients.

PATIENTS AND METHODS

Patient identification

This was a retrospective analysis of data from the Tsuchiya General Hospital undertaken between June 2006 and February 2013. Written informed consent for the procedure was obtained from all patients and patient anonymity was strictly maintained. However, informed consent for inclusion in the study was waived due to the observational nature of the study. We identified HD patients who underwent a first PTA for CVD. CVD was deemed to have occurred if any of the following criteria were met: 1) swelling or development of collateral veins in the affected ipsilateral extremity that sometimes extended to the head, neck, and chest wall on physical examination, and 2) radiological stenosis or occlusion of the subclavian vein, brachiocephalic vein, or superior vena cava. Computed tomography (CT) was indicated on the basis of the clinical signs of CVD in the patients. When clinical signs (e.g., swelling and collateral vein) were present, even if the blood flow was adequate, we performed CT and subsequently PTA for CVD, based on both the clinical signs of stenosis and radiological

examination. Clinical manifestations were recorded for each patient after a medical chart review. Data were collected on demographic characteristics, vascular access type and location, HD vintage, history of dialysis CVC or pacemaker placement, and HD status at the diagnosis of CVD. The following data were also collected for 15 of the 26 patients: Kt/V (a urea-based measure of dialysis adequacy), normalized protein catabolic rate (nPCR), venous counter pressure at dialysis, brachial artery (BA) flow volume, and resistance index (RI) of the vascular access site as determined by ultrasonography, and left ventricular ejection fraction (LVEF) and expiration inferior vena cava (IVC) diameters as determined by echocardiography, using a General Electric VIVID 7 system with M4S probe (1.5-4.3 MHz), before and 1-2 weeks after PTA. Both evaluations were implemented before HD. RI is calculated as (peak systolic velocity – peak diastolic velocity)/ peak systolic velocity. LVEF is derived from the LV end-diastolic and end-systolic volumes measured using the biplane modified Simpson's rule and the area-length method, as recommended by the American Society of Echocardiography (20). The diameter of the IVC on expiration was measured approximately 1 cm distal to the right atrium (RA) in a long-axis view.

Pre-procedural assessment

Of the 26 study patients, 19 underwent CVD examination by contrast-enhanced CT angiography. Since January 2012, we performed contrast-enhanced CT angiography before PTA in 8 of 9 patients and determined treatment strategies.

Methods and techniques for percutaneous transluminal angioplasty

Using a transbrachial and/or transfemoral approach, balloon dilation with a semi-compliant balloon was performed. Stent placement was performed for CVD that was resistant or unresponsive to balloon dilation. Balloon and stent sizes were determined according to the diameter of the adjacent normal vein. Since December 2011, we have performed intravascular ultrasound (21, 22) and monitored intra-access pressure during the procedure. Even if good patency is provided by balloon dilation, we performed additional balloon dilation or stent placement when a significant pressure difference (≥5 mmHg) exists between the central and peripheral sides of the CVD lesion. Technical success was defined as less than 30% residual stenosis.

Short-term clinical outcomes

We reviewed post-procedural complications. Primary patency was defined as the length of time from angioplasty until reintervention, or the time of patency measurement.

Statistical analysis

Data were analyzed using the Statistical Package for the Social Sciences 14 software (SPSS Inc., Chicago, Illinois, USA) and expressed as either the number of participants or the percentage (%) of the study population. The remaining data were expressed as means and ranges. Kt/V, nPCR, venous counter pressure at dialysis, BA blood flow, RI, LVEF, expiration IVC diameter, and the intra-access pressure difference were analyzed by paired t-tests with statistical significance determined at p value less than 0.05.

RESULTS

Patient characteristics

Twenty-six HD patients with CVD were treated by PTA between June 2006 and February 2013. Patient characteristics are summarized in Table I (PULL OUT TAB ON LEFT TO SEE TABLE). Seventeen men and nine women with a mean age of 69 (range, 40-96) years comprised the study population. The mean HD vintage was 75 (range, 1-188) months. The vascular access site was on the left forearm in 23 patients and on the right forearm in 3 patients. Of the 23 patients with a left forearm access, 22 had an AVF and 1 had an arteriovenous graft (AVG). Of the 3 patients with a right forearm access, 2 had an

AVF and 1 had an AVG. The mean duration between vascular access creation and the first PTA for CVD was 56 (range, 1-177) months. Of the 26 patients, 13 initiated HD therapy with a CVC placed in the right (n=9) or left (n=4) internal jugular vein (IJV) before vascular access creation. Ipsilateral CVC placement was performed in only 6 patients (23%). The remaining patient initiated HD therapy with a CVC placed in the right femoral vein. No patient had a history of pacemaker wire placement. The sites of CVD were as follows: left brachiocephalic vein (LBCV; n=13), left subclavian vein (LSCV; n=7), both LBCV and LSCV (n=3), right BCV (RBCV; n=2), and right SCV (RSCV; n=1) (Fig. 1). Of the 26 patients, 9 had extremity swelling, and 9 had both extremity swelling and collateral veins in the ipsilateral extremity. The remaining 8 patients had mild extremity swelling, and in these patients, the blood flow was reduced before the PTA due to stenosis in the anastomosis lesions.

Hemodialysis status at the diagnosis of CVD

During HD, heparin was used as an anticoagulant, and high-flux membrane dialyzers were used in all cases. The mean blood flow during HD and the maximum interdialytic weight gain rate were 225 (range, 150-300) ml/min and 5.4% (range, 0%-12%), respectively. In all patients, systolic blood pressure stabilized at 90-160 mmHg during HD without the use of a vasopressor.

Contrast-enhanced computed tomography findings

Of the 11 patients with LBCV disease, compression of the LBCV by the brachiocephalic artery or ascending aorta was apparent in 10 (91%). Of the 6 patients with LSCV disease, compression of the LSCV between the clavicle and first rib was apparent in 3 (50%). Of the 2 patients with right CVD, compression of the central vein by the surrounding tissue was not apparent in either of them.

Angiographic findings and percutaneous transluminal angioplasty

PTA data are summarized in Table I. Of the 26 patients, 19 had stenosis and 7 had occlusion. The mean length of CVD was 34 (5-80) mm. Balloon size was 5 mm (n=3), 8 mm (n=5), 9 mm (n=3), 10 mm (n=7), 12 mm (n=5), 14 mm (n=1), or unknown (n=2), and the mean maximum balloon inflation pressure was 9.1 (2-16) atm. Of the 26 patients, 8 patients underwent stent placement after balloon dilation (LBCV, n=4; LSCV, n=1; LBCV and LSCV, n=1; RBCV, n=1; RSCV, n=1). Six self-expandable and two balloon-expandable stents were delivered. The stent size was 8 mm (n=1), 10 mm (n=5), 12 mm (n=1), or 14 mm (n=1). The mean intra-access pressure differences were significantly decreased from 32 (range, 20-62) to 1.4 (range, 0-4) mmHg by PTA (n=5; p=0.02).

Dialysis efficacy, vascular access flow, and cardiac function (pre versus post-percutaneous transluminal angioplasty)

The pre and post-PTA dialysis efficacy, vascular access flow, and cardiac function of 15 of the 26 patients are summarized in Table II (PULL OUT TAB ON LEFT TO SEE TABLE). Means of the following parameters were not significantly different before and after PTA: Kt/V (1.68 [range, 1.34-2.31] versus 1.66 [1.10-2.27], P=0.7), nPCR (1.10 [0.71-1.67] versus 1.05 [0.66-1.43] g/kg/day; p=0.4), and venous counter pressure at dialysis (mean for consecutive three times) (139 [91-177] versus 134 [77-168] mmHg; P=0.4). Compared with the pre-PTA value, the mean BA flow volume was significantly increased after PTA (957 [290-1554] versus 1306 [339-2274] ml/min; p=0.005). However, the mean BA RI (0.54 [0.32-0.65] versus 0.52 [0.38-0.68]; p=0.3), LVEF (60% [35%-74%] versus 57% [34%-65%]; p=0.2), and expiration IVC diameter (17 [6-24] versus 17 [9-25] mm; p=0.9) were the same before and after PTA.

Short-term clinical outcomes

In 25 out of the 26 patients (96%), the vascular accesses were salvaged by PTA without any complications, indicating technical and clinical success. In the remaining case, balloon dilation was stopped halfway through owing to the occurrence of chest pain. In

all patients, the symptoms caused by CVD improved after PTA. The reintervention rate was 62% (16/26). The primary patency rate at 3, 6, 9, and 12 months was 81% (21/26), 73% (19/26), 65% (17/26), and 57% (13/23), respectively (Tab. I). The overall 90-day survival rate was 100%.

DISCUSSION

CVD is a significant complication in HD patients. The incidence of CVD has been reported to be in the range of 14%-40% in the literature (11). Strong association of CVD with previous placement of CVCs and pacemaker wires has been reported (13). However, in the present study, extrinsic compression is considered a fundamental factor for CVD because the rate of extrinsic compression of LBCV and LSCV was higher than that of previous CVC placement.

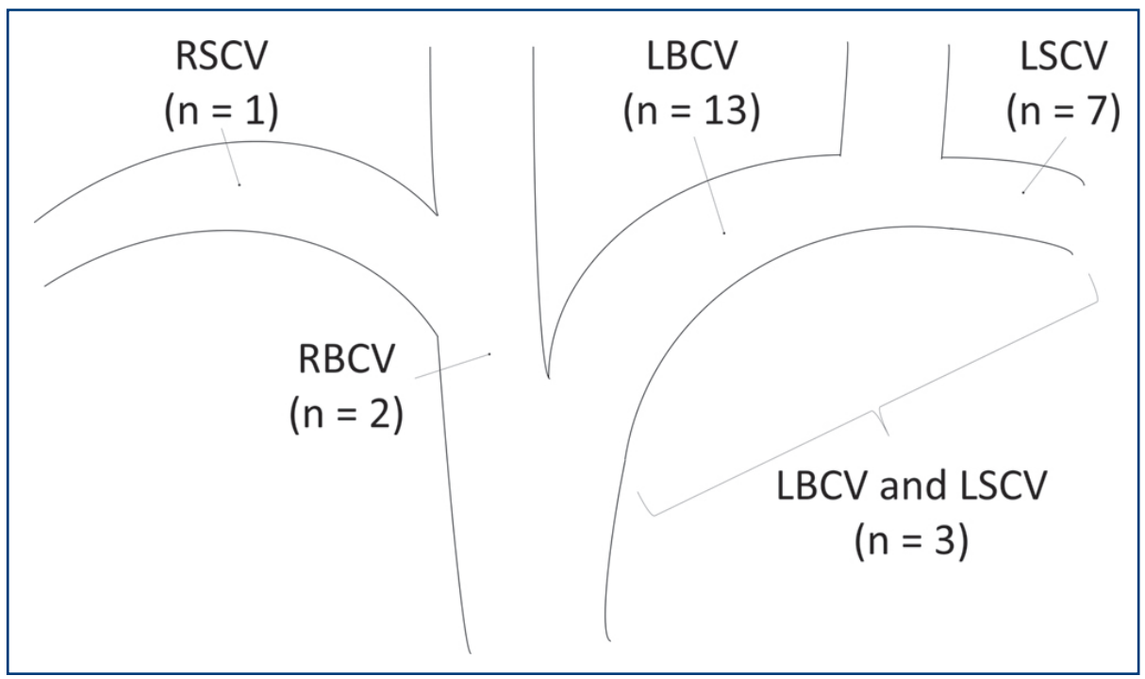
One of the largest studies on PTA for CVD, comprising 47 patients, showed a technical success rate of 77% and a primary patency rate of 58% at 3 months, 45% at 6 months, and 29% at 12 months (23). The results of PTA for CVD in our study were excellent by comparison.

Cardiac failure is a life-threatening complication in HD patients. Although satisfactory vascular access flow is necessary for dialysis adequacy, high vascular access flow induces high-output cardiac failure (19, 24). Horita et al reported that increased vascular access flow after PTA for CVD resulted in increased RA and right ventricle diameters, but these changes were completely recovered. Moreover, there were no significant pre and post-PTA differences in LVEF (25). However, the flow volume of the vascular access was not evaluated, and their study included only six patients. In the present study, although ipsilateral BA flow, which reflects vascular access flow, significantly increased after PTA compared with its pre-PTA value, the LVEF and expiration IVC diameter, which reflect RA pressure, were the same before and after PTA. These findings suggest that increased vascular access flow after PTA for CVD has no relation to cardiac function. The existence of collateral veins is believed to be the reason for the lack of a significant difference before and after PTA in dialysis efficacy, venous counter pressure at dialysis, and BA RI. The development of collateral veins may prevent the increase of venous counter pressure or BA RI due to CVD. Moreover, there were no significant hemodynamic changes after PTA, with the exception of minor increases in access flow. This relatively small change may explain the lack of observed cardiovascular changes.

This study has several limitations. First, this study was based on a group of patients being treated at a single center and the sample size was small. Second, the association between previous

Figure 1

Distribution of central venous stenosis or occlusion. Values are expressed as the number of patients. LBCV = left brachiocephalic vein; LSCV = left subclavian vein; RBCV = right brachiocephalic vein; RSCV = right subclavian vein.



ipsilateral CVC placement and CVD was not examined sufficiently because at our institution, the CVC side was usually on the right and the vascular access side was usually on the left. Finally, the association between increased vascular access flow after PTA and cardiac function in HD patients with low cardiac function was not examined sufficiently. We believe that further studies with a larger sample size are needed to confirm our findings. However, given the small number of published papers that have examined outcomes including vascular access flow and cardiac function in HD patients with CVD, our study is valuable relative to the existing information in the field.

Among HD patients, CVD may be caused by extrinsic compression rather than previous ipsilateral dialysis catheter placement in the IJV. The results of PTA for CVD were comparatively excellent. Our findings suggest that increased vascular access flow after PTA for CVD has no relation to cardiac function.

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TABLE I

PATIENT CHARACTERISTICS, ANGIOGRAPHIC FINDINGS, AND PERCUTANEOUS TRANSLUMINAL ANGIOPLASTY

Variable	N=26
Age (range)	69 (40-96) years
Male (female)	17 (9)
Hemodialysis vintage (range)	75 (1-188) months
VA location	
Left forearm (AVF/AVG)	23 (22/1)
Right forearm (AVF/AVG)	3 (2/1)
Mean duration between VA creation and first PTA (range)	56 (1-177) months
Dialysis with CVC before VA creation	14
Right internal jugular vein	9
Left internal jugular vein	4
Right femoral vein	1
Ipsilateral dialysis CVC placement before VA creation	6 (23%)
History of pacemaker wire	0 (0%)
Stenosis/occlusion	19/7
Mean length of stenosis or occlusion (range)	33 (5-80) mm
Balloon dilation alone/stent placement after balloon dilation	18/8
Technical success	25/26 (96%)
Primary patency rate (from first to next PTA)	
3 months	21/26 (81%)
6 months	19/26 (73%)
9 months	17/26 (65%)
12 months	13/23 (57%)

AVF = arteriovenous fistula; AVG = arteriovenous graft; CVC = central venous catheter; PTA = percutaneous transluminal angioplasty; VA = vascular access.

TABLE II

DIALYSIS EFFICACY, VASCULAR ACCESS FLOW, AND CARDIAC FUNCTION (PRE- VERSUS POST-PERCUTANEOUS TRANSLUMINAL ANGIOPLASTY)

Variable	Pre-PTA (range)	Post-PTA (range)	P
Kt/V	1.68 (1.34-2.31)	1.66 (1.10-2.27)	0.7
nPCR (g · kg-1 · day-1)	1.10 (0.71-1.67)	1.05 (0.66-1.43)	0.4
Venous counter pressure at dialysis (mmHg)	139 (91-177)	134 (77-168)	0.4
Brachial artery blood flow (mL/min)	957 (290-1554)	1306 (339-2274)	0.005
Brachial artery resistance index	0.54 (0.32-0.65)	0.52 (0.38-0.68)	0.3
Left ventricular ejection fraction (%)	60 (35-74)	57 (34-65)	0.2
Expiration inferior vena cava diameter (mm)	17 (6-24)	17 (9-25)	0.9

Kt/V = a urea-based measure of dialysis adequacy; nPCR = normalized protein catabolic rate; PTA = percutaneous transluminal angioplasty.

To see original article on JVA website visit:
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1. Hyer W & Fell JM. Screening for familial adenomatous polyposis. Arch Dis Child 2001; 8:377–381.

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