Cost of vascular access devices in public hospitals in Queensland

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Abstract
Objective. The aim of this study was to quantify the utilisation of vascular access devices in Queensland public hospitals and their associated cost.

Methods. Devices were broadly classified into peripheral intravenous catheters, central venous catheters and arterial lines. The number of catheters used was obtained from a central procurement department at Queensland Health and validated using Medicare Benefits Schedule (MBS) claims and/or hospital data from the Australian Institute of Health and Welfare for the same period. Resources consumed included equipment and staff time required to insert and remove catheters. Equipment costs were valued using negotiated hospital prices, and staff time was valued at the fixed industrial award wages in Australia or relevant MBS fees. Device maintenance costs (e.g. dressings) and costs of treating complications were excluded.

Results. Approximately 2.75 million vascular access devices were used in public hospitals in Queensland in 2016, at a total cost of A$59.14 million. This comprised a total equipment cost of around A$10.17 million and a total labour cost of A$48.85 million.

Conclusion. Vascular access is an important component of healthcare expenditure. The present study is the first to characterise and cost vascular access devices in Queensland. Further research is needed on the costs of maintaining device function and of treating complications associated with vascular access.

What is known about the topic? The cost of vascular access in Australia has previously been estimated from modelling, using various assumptions, or based on device utilisation in other countries.

What does this paper add? For the first time, device utilisation for vascular access in Queensland has been quantified and costs. Results were obtained from reliable sources and validated against other databases.

What are the implications for practitioners? Practitioners and managers may now provide accurate estimates about the cost of catheter failure, a potentially preventable problem that affects up to 50% of all catheters placed. Attaching costs to such failure may also stimulate research into how to reduce the problem.

Additional keywords: economic evaluation, equipment costs, intravenous catheterisation, staff costs.

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Introduction

The history of vascular access is long, spanning five centuries. The first animal-to-animal transfusions occurred in the mid-1600s, and experimental infusions of medications, delivered via a quill, began in the same century. However, it was not until 1818 that the first successful blood transfusion was performed, following a postpartum haemorrhage. Since then, devices for the delivery of parenteral treatment through the human vasculature has continued to develop. Important milestones included the replacement of rubber tubing for delivering fluids with plastic tubing, the use of vacuum bags to reduce the risk of microbial growth in intravenous solutions and the development of hollow steel needles, which were replaced in the 1950s by polyethylene devices and later by latex rubber, polytetrafluoroethylene, polyurethane and silicone, including various antimicrobial- and antithrombogenic-coated or -impregnated devices.

In the modern era, several types of vascular access devices (VADs) are in use. The most common is the peripheral intravenous catheter (PIVC), which is a small, flexible tube placed in a peripheral vein and secured to the skin with an adhesive dressing plus tape or a securement device. PIVCs are designed for short-term use to deliver medications and fluids. Central venous access devices (CVAD) are used when longer-term therapy, such as chemotherapy or haemodialysis, is required; CVAD are long, flexible tubes placed in large veins of the neck, chest or groin. These catheters may also be inserted into a peripheral vein in the arm, known as peripherally inserted central catheters (PICC). CVADs, including PICCs, may be either non-tunnelled or tunnelled. Non-tunnelled catheters are fixed to the skin, as with PIVCs, at the insertion site. Tunnelled catheters, as the name suggests, are tunnelled under the skin, from the insertion site to an exit site, often on the chest. Tunnelling enables a patient on long-term therapy to be discharged from hospital with the device in situ, whereas a non-tunnelled device is usually removed before hospital discharge. A totally implanted vascular device is a smaller reservoir port device, surgically positioned in the vein and entirely under the skin. This device requires access with a needle through the skin into the port. These devices are used for long-term therapy, such as for the frequent administration of drugs, parenteral nutrition or transfusions. Medications are administered through the skin into the port, to reduce the chance of catheter-related infection. Midline catheters fall between PIVCs and CVADs in terms of length, at around 8–12 cm, and are placed in the upper arm. The dwell time may be up to 50 days, which is similar to a PICC; the use of midline catheters is also similar to that of PICCs, that is, for the administration of medium-term therapies. The advantage of a midline catheter over a PICC is that the tip placement is proximal to the axilla, so the central venous system is not entered, thus reducing the risk of a catheter-related bloodstream infection. Finally, peripheral arterial catheters (AC) are thin tubes, usually placed in the radial or femoral artery, that are used for monitoring intra-arterial blood pressure and arterial blood gases. Their use is short term and usually limited to intensive care or anaesthetic settings.

Although much is known and documented about the development of VADs, particularly when a new product comes onto the market, less is known about the volume used. It is not uncommon to find statements claiming that up to 70% of hospital patients receive a PIVC or about the wide use of PICCs in cancer patients, but quantifying the use of total devices is more difficult. Some reports contain specific details, such as up to 25 million PIVCs are placed in France every year or that around 330 million PIVCs are sold in the US each year, but these statements are frequently based on citations from earlier reports, which themselves are often unclear estimates. For example, information for the French reference above was extracted from a 2005 report but, in that report, it was unclear from where the estimate of 25 million catheters came. Similarly, the US data were cited from a 2012 publication that cited 330 million catheters, based on unpublished industry estimate of sales.

In an Australian context, we have no large-scale evidence about the annual use of VADs and their cost. Without this information it is not possible to estimate savings that could be made if intravenous practices could be improved. For example, many inserted devices are never used, and around 25% of insertions require multiple attempts, particularly in those patients who are difficult to cannulate, such as the obese and those who have vascular damage due to age or frequent cannulation. In addition, up to 50% of devices fail for various reasons, such as phlebitis, occlusion, infiltration, blockage or dislodgement before treatment has been completed, requiring a replacement device. Being able to apply a cost value to these problems may incentivise organisations to be more proactive in preventing unnecessary catheter insertion, to use expertinserters to increase the likelihood of first-attempt success and to optimise postinsertion care to prevent device failure. Consequently, the aim of the present study was to quantify the use of various VADs in Queensland public hospitals and the associated cost.

Methods

Our approach was to identify, measure and value the VADs used from the perspective of the State Health Department, Queensland Health.

We broadly classified devices into PIVCs, CVADs and ACs. CVADs were subdivided into PICCs, tunnelled and non-tunnelled central venous catheters and implanted ports. Midline catheters were not included in the study because midline catheters are not purchased for use in Queensland public hospitals. To estimate the annual number of devices used by public hospitals in Queensland, purchase data were used as a proxy for the volume of utilisation. The number of devices purchased in 2016 was obtained from the Strategic Procurement and Supply Service at Health Support Queensland, which is the central department for purchasing and distributing devices to public hospitals in Queensland. Purchase data were obtained from this department through an official data request.

Health resources consumed included equipment and staff time required to insert and remove catheters. Equipment costs were valued using negotiated hospital prices in 2016 for both the catheter sets and insertion-related accessory devices (e.g. guidewires). In the presence of multiple brands of the same device type, the weighted average prices were calculated based on the number of catheters consumed of each brand. Staff time associated with PIVC use was estimated at 15 min
for insertion and 4.5 min for removal,\textsuperscript{15} with time valued based on 2016 fixed industrial award wages in Australia. Staff time for inserting and removing other VADs and ACs was valued based on Medicare Benefits Schedule (MBS) fees in 2016 (Table 1). Device to MBS item match was guided by expert opinion (NM and NG) and verified independently by a claim unit in a leading hospital in Brisbane. We did not include the costs of maintaining VADs while in use (e.g. infusion therapy or dressings used). All costs are reported in Australian dollars (A$) in 2016 prices (A$1 = US$0.75).

To validate our results, we compared our estimates of the number of devices consumed with the number of relevant MBS claims and/or hospital data from the Australian Institute of Health and Welfare (AIHW) for the same period.

Results

Approximately 2.75 million VADs were used in public hospitals in Queensland in 2016 at a total cost of A$59.14 million. Most catheters used were PIVCs (2 690 000; 97.8%) followed by ACs (33 700; 1.2%) and CVADs (26 500; 1.0%).

Total equipment cost was around A$10.17 million, with A$6.13 million (60.2%) for PIVCs, A$3.31 million (32.5%) for CVADs and A$0.73 million for ACs (7.3%). Total labour cost was A$48.85 million, with A$34.92 million (71.5%) for PIVCs, A$9.26 million (19.0%) for CVADs and A$4.66 million (9.5%) for ACs. Table 2 summarises total costs for the devices included in the present study.

Our estimates of device utilisation were close to the estimates obtained from other data sources (within a 10% margin). For example, using an epidemiological approach based on the number of hospitalised patients from the AIHW (for details, see Table 3), approximately 2.4 million PIVCs could be used annually in public hospitals in Queensland.\textsuperscript{16} Furthermore, using MBS claims for Queensland in 2016 indicated that around 10 241 PICCs (vs 9757 from the present study), 667 tunnelled catheters (vs 535) and 33 000 arterial lines (vs 33 657) would be used each year.\textsuperscript{17} Table 3 compares device utilisation estimates from various data sources.

Discussion

This study is the first to characterise the number and cost of VADs used in Queensland. Many of these devices (up to 50%) are only used because a previous device in that patient failed. Thus, we may also begin to calculate costs associated with both insertion failure and postinsertion device failure, as well as placement of unnecessary devices.\textsuperscript{7,18,19} Putting a figure around this waste may prompt a greater emphasis on finding solutions to vascular access challenges. The study is also important because it provides an insight into the types of VADs used in Queensland, which may allow for comparisons with other jurisdictions where similar practices are adopted. For example, midline catheters are rarely used in Australia, but are used elsewhere as an alternative to inserting a PICC or to avoid frequent PIVC replacement. There are now evidence-based

<table>
<thead>
<tr>
<th>VAD, vascular access device; PIVC, peripherally inserted venous catheter; PICC, peripherally inserted central catheter; MBS, Medicare Benefits Schedule</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>VAD</strong></td>
</tr>
<tr>
<td>---</td>
</tr>
<tr>
<td>PIVCs</td>
</tr>
<tr>
<td>PICCs Adult: 83.00</td>
</tr>
<tr>
<td>Paediatric: 227.50</td>
</tr>
<tr>
<td>Tunnelled Adult: 272.40</td>
</tr>
<tr>
<td>Paediatric: 354.00</td>
</tr>
<tr>
<td>Non-tunnelled Adult: 83.00</td>
</tr>
<tr>
<td>Paediatric: 227.50</td>
</tr>
<tr>
<td>Implanted ports Adult: 551.60</td>
</tr>
<tr>
<td>Paediatric: 717.10</td>
</tr>
<tr>
<td>Arterial lines 69.30</td>
</tr>
</tbody>
</table>

\textsuperscript{1}Paediatrics used PICCs of \textless 5 Fr.

\textsuperscript{2}Paediatrics used non-tunnelled catheters of \textless 6 Fr.

Table 2. Summary of vascular access device use and cost in public hospitals in Queensland in 2016 (Health Services Queensland procurement numbers)

<table>
<thead>
<tr>
<th>Type</th>
<th>No. catheters</th>
<th>Equipment cost (A$)</th>
<th>Labour cost (A$)</th>
<th>Accessories cost (A$)</th>
<th>Total cost (A$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PIVC</td>
<td>2 686 315</td>
<td>6 131 701</td>
<td>34 922 095</td>
<td>41 053 796</td>
<td></td>
</tr>
<tr>
<td>Tunnelled</td>
<td>535</td>
<td>115 611</td>
<td>2 719 903</td>
<td>3 543 003</td>
<td></td>
</tr>
<tr>
<td>PICC</td>
<td>9757</td>
<td>1 232 229</td>
<td>3 307 843</td>
<td>4 545 056</td>
<td></td>
</tr>
<tr>
<td>Non-tunnelled</td>
<td>14 081</td>
<td>1 049 979</td>
<td>4 145 641</td>
<td>5 291 970</td>
<td></td>
</tr>
<tr>
<td>Implanted ports</td>
<td>33 657</td>
<td>7 337 979</td>
<td>4 664 860</td>
<td>5 420 036</td>
<td></td>
</tr>
<tr>
<td>Arterial</td>
<td>2 746 371</td>
<td>10 175 017</td>
<td>48 849 998</td>
<td>118 202</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>2 746 371</td>
<td>10 175 017</td>
<td>48 849 998</td>
<td>118 202</td>
<td></td>
</tr>
</tbody>
</table>

Vascular access cost in Queensland

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indications for the use of midline catheters;\textsuperscript{20} the use of these devices may reduce costs, avoid multiple PIVC insertions and prevent complications associated with central venous access.

We have shown that the total annual cost of vascular access is nearly A$60 million in public hospitals in Queensland. Based on the Admitted Patient Care Report 2015–2016 by the Australian Institute of Health and Welfare, there were 1,292,391 separations in public hospitals in Queensland;\textsuperscript{21} thus, the cost per separation is around A$46. These estimates approximate the VAD cost in public and private hospitals in Queensland and in Australia. For example, the number of separations in private hospitals in Queensland in 2015–16 was 1,072,557;\textsuperscript{21} thus, the separation distribution of the 2,364,948 episodes in public and private hospitals is 55% public : 45% private.\textsuperscript{21}

Accordingly, and assuming similar practices across hospitals in the State, the cost of vascular access in Queensland’s private hospitals is around A$50 million, and the total annual cost in both private and public hospitals is around A$110 million. Given that the total acute public and private hospital separations in Queensland represent 22% of the 10,585,288 total hospital separations in Australia,\textsuperscript{21} the total annual cost of VADs in the country may be around A$500 million. This number is expected to increase with population growth.

Importantly, with currently substantial rates of potentially preventable device failure, A$90–180 million dollars could be saved annually in Australia by improving VAD practices.

**Strengths and limitations**

A major strength of the present study is that data were derived from one source, a central department in Queensland Health, using negotiated hospital prices, which means that we did not have to model or make many assumptions to estimate device utilisation. Furthermore, the results were validated using other data sources (e.g. MBS claims and/or hospital data from the AIHW when available). Using MBS claims instead of the figures from the central procurement unit may not be accurate because not all the devices included in the present study can be claimed through the MBS. For example, there is no MBS item for PICCs. However, the results were verified by experts and compared with other data sources.

There were some limitations to the study. Data were from one jurisdiction (public hospitals in Queensland); however, this should not differ much from the practice in other states. Further, certain assumptions were made to match MBS items to devices, especially that some MBS items were used for more than one device type; however, this was informed by expert opinion. Moreover, it was beyond the scope of this study to include the cost of maintaining devices while in place (e.g. dressings or flushing) or the cost of diagnosing and treating complications, such as primary bloodstream infections, which have a current cost of A$6351.94,\textsuperscript{21} or of troubleshooting complications, such as expensive antithrombotics for catheter occlusion. If these costs were added, the overall burden of catheter use and failure would be much higher, and further research is needed to provide a full picture. Another limitation is that other types of devices (e.g. midline or intraosseous device) were not included in the study. However, these are not used as commonly as the catheters included in the analysis, and therefore may not significantly alter the overall conclusions of the paper. Finally, there is an inherent difference between procurement and utilisation; that is, what is purchased is only a proxy for what is used. However, inventory levels are likely to remain stable with just-in-time procurement and so it is unlikely that over the observation period stock-on-hand levels were likely to differ significantly between the beginning and end of the period. Therefore, procurement of devices is likely to be a very close proxy for utilisation.

**Implications for research and practice**

A national clinical registry designed to document VAD utilisation and capture outcomes associated with various devices would be useful to inform practice and policy decisions about device selection and improved quality and safety of care. To decrease the incidence of device failure, further research into insertion and postinsertion strategies (e.g. securement) is also required. In addition, to reduce the number of devices placed, health system policies should be updated to reflect existing evidence related supporting clinically justified rather than routine time-based removal of PIVCs, so unnecessary waste and procedures may be avoided.

**Conclusion**

Vascular access is an important component of healthcare expenditure. The present study is the first to characterise and cost the use of VADs in Queensland.

**Conflict of interest**

The authors declare no conflicts of interest.
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