Endovascular management of some catheter-related mechanical complications

Thesis

Submitted for partial fulfillment of Master degree in general surgery

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بناء على موافقة الجامعة بتاريخ / / ٢٠٠ تم تشكيل لجنة الفحص والمناقشة الرسالة المذكورة أعلاه على النحو التالي :-

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بعد فحص الرسالة بواسطة كل عضو منفردا وكتابة تقارير منفردة لكل منهم انعقدت اللجنة مجتمعة في يوم .... بتاريخ / / ٢٠٠ بقسم .... مدرج ....
بكلية الطب – جامعة القاهرة وذلك لمناقشة الطالب في جلسة علنية في موضوع الرسالة والنتائج التي توصل اليها وكذلك الأسس العلمية التي قام عليها البحث .

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[signature]	[signature]	[signature]

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LIST OF ABBREVIATIONS

- ACF: Aorto-caval fistula
- AV: Arterio-venous
- AVF: Arterio-venous fistula
- CFA: Common femoral artery
- CVC: Central venous catheters
- FV: Femoral vein
- IJV: Internal jugular vein
- IMA: Internal mammary artery
- MRI: magnetic resonance imaging
- PAT: Polyethylene tetraphythalate
- PCI: Percutanous cardiac intervention
- PICC: Peripherally inserted central catheter
- PIVAS: Partially implantable venous access system
- PP: polypropylene
- PTFE: polytetrafluroethylene
- PU: polyurethane
- PVC: polyvinyl chloride
- SCV: Subclavian vein
- SVC: Superior vena cava
- TIVAS: Totally implantable venous access system

Abstract

Vascular catheters related mechanical complications may be associated with central venous catheters (CVCs) or with those used for endovascular procedures. Mechanical complications associated with CVCs are classified as secondary to insertion, indwelling and extraction. Arterio-venous fistulas, pseudo-aneurysms and catheter fragment embolism are rare but may be life threatening complications. The aim of this study is to highlight the simple influential role of the endovascular procedures in treatment of some of these complications. This study included 957 patients either subjected to indwelling CVCs insertion (831) or arterial endovascular procedure (126). The predisposing factors behind these complications were studied in relation to their time of occurrence. Nine challenging complications occurred in eight patients; one iatrogenic arterio-venous fistula, one false aneurysm and 7 foreign body catheter embolism. Early recognition of such complications and timely intervention by using the standard endovascular tools or modifying the available ones obviated the hazardous and may be life threatening consequences.

Key words: endovascular, central venous catheters, mechanical complications, iatrogenic AVF, false aneurysm and catheter embolism.

INTRODUCTION

Millions of central venous catheters (CVCs) are inserted yearly worldwide. Yet, the impact of the possible complications associated with CVC insertion or use is so important that efforts to minimize and prevent their occurrence should be a routine element of quality improvement programs.

These complications are broadly categorized as: thrombotic complications, infection and mechanical complications. Mechanical complications associated with central venous catheters (CVCs) are furthersub-classified as secondary to insertion, indwelling and/or extraction.

Arterio-venous fistulas, pseudo-aneurysms and catheter embolism are examplesfor serious mechanical complications that necessitate early recognition and timely intervention to obviate the hazardous and may be life threatening consequences.

The aim of this study is to highlight the simple influential role of the endovascular procedures by using the standard endovascular tools or modifying the available ones in treatment of such complications.

Review of literature

Vascular Catheters

The earliest documented vascular catheter was a sharpened quill from a bird's feather used by Sir Christopher Wren in England in the 17th century in early intravenous infusion experiments on animals. However the quills could not easily be sterilized and, as a "foreign" object made of protein, elicited an intense inflammatory response. In the 19th century, hypodermic needles and syringes were invented which allowed reliable intravenous administration, but these rigid metal cannulas were unsuitable for long-term use due to the injury and thrombosis they provoke within blood vessels. In 1929, Forssmann demonstrated that it was possible to advance a flexible tube through his own arm vein into the right atrium using a latex ureteric catheter, a reactive material which would be unsuitable for chronic implantation. The availability of plastic polymers such as polyethylene (PE), polypropylene (PP), polyvinyl chloride (PVC) and fluorocarbons as poly-tetra-fluoro-ethylene (PTFE) provided tubing that began to meet many of the properties required for intravascular implantation. However, these materials were relatively still thrombogenic as they were quite rigid, contributing to endothelial injury ***(Swindle et al. 2005).***

In the early 1940s the development of silicone polymers provided materials that offered greater bio-compatibility and stability for long-term implantation particularly due to reduced thrombogenicity***(Colas & Curtis 2004).*** Vascular catheters and also intravascular implants which come into contact with blood become rapidly coated in a biofilm derived from the circulating blood. That biofilm acts as a substrate for both thrombosis and microbial colonization ***(Passerini et al., 1992).***More recent developments in biocompatible polyurethane materials (PU) have provided catheter materials with physical properties which are superior to silicones due to different quality and quantity of the biofilm that forms ***(Brown 1995).***

Desirable properties of vascular catheter materials:

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The desirable properties for optimal vascular catheter materials are shown in table (1):

Table (1): Properties of optimum vascular catheter material:

Biological • Non-irritant - provokes minimal inflammatory response • Non-toxic • Non-carcinogenic • Non-thrombogenic • Resists bio-film deposition and microbial adhesion
Physical • High tensile strength • Resists compression - maintains patent lumen • Optimum flexibilityand dimensional stability • Low friction coefficient • Tolerates physical sterilization methods (e.g. heat, steam, irradiation) • Ease of fabrication (e.g. heat forming or welding) • Non-permeable (water, gases, solvents) • Radio-opacity: ability to image catheter with X-rays • MRI (Magnetic Resonance Imaging) compatible
Chemical • Absence of leachable additives (e.g. catalysts and plasticisers) • Stable during storage • Stable on chemical sterilization • Stable on implantation (non-biodegradable) • Permits adhesives in fabrication (possibility of bonding dissimilar materials) • Accepts surface coatings (e.g. hydrogel, antithrombotic, antibacterial) • Compatibility with chemical compounds and solvents (absence of absorption and chemical reaction)

In practice, there is no single material that can be used for all applications and therefore catheter materials need to be selected based on assessment of the intended application. For example: flexible catheters can reduce endothelial injury which can lead to thrombosis, but they may be more difficult to insert.

Types of vascular catheters:

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Two main broad types of vascular catheters are available according to the field of their use: A) Catheters used for drugs or fluid administration, blood sampling, and monitoring.

B) Catheters used for endovascular procedures.

A) Catheters used for drugs/ fluid administration, blood withdrawal or transfusion, and for monitoring:

1-<u>PeripheralCatheters</u> (Cannulas)(fig.1)

These catheters are designed usually for cannulation of peripheral veins.They are typically short (usually 5 cm in length) and about 14-24 gauge in diameter. These catheters are usually inserted using a catheter-over-needle device; the catheter fits snugly over the needle, and has a tapered end to minimize damage to the catheter tip and soft tissues during insertion. The needle has a clear hub, called a flash chamber, which fills with blood when the tip of the needle enters the lumen of a blood vessel. When the tip of the needle enters the blood vessel the catheter is advanced over the needle into the lumen of the vessel***(Marino 2007).***

14 16 18 20 22 24

Figure.1:Peripheral catheter. (medisave.co.uk)

2-<u>Butterfly Catheter Infusion Sets</u>(fig.2)

These Butterfly Infusion Sets consist of a stainless steel needle with butterfly wings, a length of tubing and an adapter. This adapter fits any standard IV, blood set or syringe and contains a flange to accept secure lock.

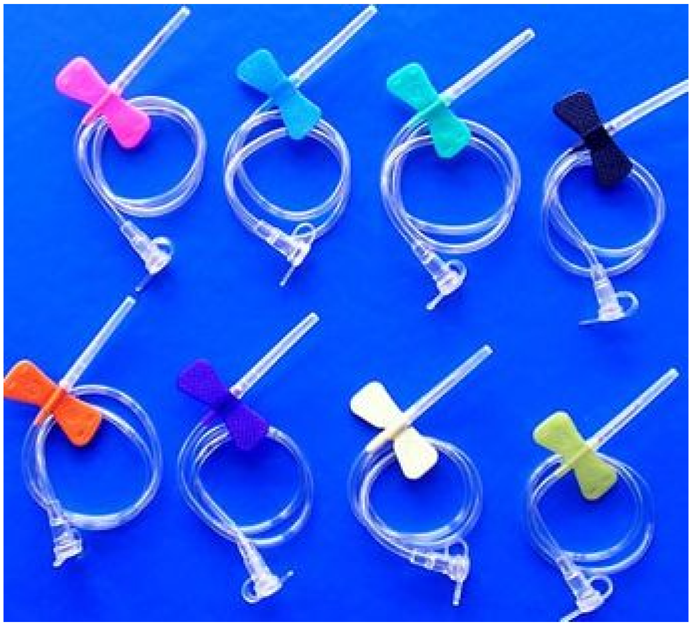

Figure 2: Butterfly catheters (B-Braun catalog 2009)

3-<u>Peripherally Inserted Central Catheters</u> (PICCs) (fig.3)

They are long catheters (50-60 cm in length) made of soft silicon rubberthat can be inserted in the basilic or the cephalic vein in the arm and advanced into the superior vena cava. These PICCs offer one advantage over cannulation of the more centrally located subclavian or internal jugular veins: i.e., there is no risk of pneumothorax ***(Marino 2007).***