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Ventricular perforation associated with central venous introducer-dilator systems

Purpose: Cardiac perforation is a recognised complication of guidewire-introducer techniques. These two new cases of right ventricular perforation implicate the dilator-introducer: one directly and the other due to presumed guidewire buckling.

Clinical Features: An 85-yr-old man underwent right subclavian cannulation for triple-lumen and pulmonary artery (PA) catheter insertion before coronary artery surgery. Tachycardia (120 bpm) and hypotension (60/30 mmHg) evolved over the next 40 min and resolved with evacuation of 200 ml of clot from the pericardial sac. A ragged 4 mm laceration of the ventricular wall was localised and oversewn without further consequence.

A 60-yr-old man with inferior vena caval thrombosis was scheduled for Greenfield filter insertion. The right internal jugular vein was cannulated using the guidewire-introducer technique. Introduction of the introducer-dilator system precipitated cardiovascular collapse. Resuscitation was unsuccessful and post-mortem revealed right ventricular perforation and pericardial tamponade.

Conclusion: These cases suggest that shorter introducer-dilators would be safer and probably equally efficacious. The need for a high index of suspicion and rapid therapeutic intervention is also highlighted.

Objectif : La perforation cardiaque est une complication bien connue de l'utilisation du guide métallique pour le cathétérisme. Deux cas de perforation ventriculaire droite mettent ici en cause le dilateur-introducteur dont la première directement, la deuxième par enroulement possible du guide métallique.

Éléments cliniques : Avant une chirurgie coronaire, on introduisait chez un homme de 85 ans une canule sous-clavière dans le but d'installer un cathéter à trois lumières dans l'artère pulmonaire. Une tachycardie (120 b·min⁻¹) avec hypotension (60/30 mmHg) survenait dans l'espace de 40 min et disparaissait après l'évacuation d'un caillot du sac péricardique. Une déchirure de 4 mm au niveau du ventricule droit était localisée et suturée sans autres conséquences. Un homme de 60 ans atteint d'une thrombose de la veine cave était programmé pour l'insertion d'un filtre de Greenshield. La veine jugulaire droite était canulée à l'aide d'un système d'introducteur à guide métallique. L'insertion d'un ensemble introducteur-dilateur précipitait un collapsus cardiovasculaire. La réanimation s'avérait impossible et l'autopsie révélait une perforation ventriculaire avec tamponnade péricardique.

Conclusion : Ces cas portent à croire que des introducteurs-dilateurs plus courts seraient moins dangereux et peut-être aussi efficaces. La nécessité de demeurer vigilant et d'intervenir rapidement est soulignée.

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THE safety of guidewire-introducer techniques has led to their universal acceptance for the percutaneous placement of central vessel catheters. Although pericardial tamponade secondary to cardiac perforation is a rare complication,¹ it is most frequently as the result of catheter erosion through the myocardium.

Two cases are described in whom acute cardiovascular collapse at the time of central venous cannulation implicated the introducer-dilator systems used to place the central catheters.

Case Report 1

An 85-yr-old man (75 kg, 173 cm) was scheduled for elective coronary artery surgery. In view of a recent episode of left ventricular failure a pulmonary artery (PA) catheter and a central venous pressure line were placed via the right subclavian route following induction of anaesthesia.

The guidewire-introducer technique was employed to place the 50 cm (Vialon Deltacath) and 70 cm (Braun Intradyne) j-wires. The more laterally placed wire (Vialon) was inserted to 15 cm and the longer wire (Braun) to 19 cm. Introduction of the triple-lumen catheter (Vialon) was uneventful. Once the 8-French Braun introducer had been inserted 3 cm beyond the skin incision three premature ventricular beats were noted; the wire was immediately withdrawn two centimetres with restoration of sinus rhythm. There were no further signs of cardiac irritability during placement of the PA catheter and passage of the catheter from the right ventricle to the pulmonary artery was smooth.

Over the next 40 minutes hypotension and tachycardia (100 bpm) developed: blood pressure decreased to 60/30 mmHg despite volume loading (10 ml·kg⁻¹), adrenaline (0.5 mg) and discontinuation of both the nitrate infusion and the volatile anaesthetic agent. Central venous and pulmonary wedge pressures were unchanged at 6 and 8 mmHg respectively. Prior to sternotomy heart rate increased to 120 bpm interrupted by occasional ventricular ectopic beats. Pericardotomy revealed fresh clot (200 ml) localised to the anterior wall of the right ventricle. After evacuation, a briskly bleeding laceration to the anterior wall of the right ventricle was revealed. The laceration was approximately 4 mm in length with a jagged perimeter situated 2 cm from the inferior heart border. Oversewing of the perforation and volume replacement (500 ml) restored haemodynamic stability and surgery proceeded uneventfully.

Case Report 2

A 60-yr-old man with extensive iliac vein thrombosis and a background of multiple myeloma underwent

insertion of a Greenfield filter (Braun Celsa 70 cm) under radiological control.

The guidewire-introducer technique was employed to cannulate the right internal jugular vein and the J-wire was screened passing down through the inferior vena cava and it was clearly visualised in the femoral vein. Immediately following introduction of the introducer-dilator, the blood pressure became unrecordable. Resuscitation was unsuccessful and post-mortem examination revealed fatal pericardial tamponade secondary to a large perforation of the inferior wall of the right ventricle.

Discussion

The reported incidence of cardiac perforation and tamponade associated with central venous cannulation is less than two per thousand.² Shah's series, published in 1984, is the largest prospective study of PA catheterisation in a population of >6,000. There was only one, non-fatal case of right ventricular perforation. In our institution, there are >2,000 central vessel catheters inserted per year. The cases described here are two of three cases of cardiac tamponade reported in the last five years. Whilst the incidence of this complication is low, the associated mortality is high (65–78% in two large series^{3,4} examining tamponade) and has not decreased since the first report in 1968.

A number of factors have been implicated in the aetiology of cardiac perforation and subsequent tamponade. Firstly, the likelihood of erosion through the walls of great vessels or the heart is influenced by catheter composition,⁵ the presence of a bevelled catheter tip and most importantly, the presence of the catheter tip within the heart.^{6,7} All catheters, whether placed via a central or a cubital vein,⁸ migrate from their original position.

Previous case reports implicate gradual catheter erosion through the heart wall over time⁶ as a sequel to intracardiac placement or migration of the catheter usually at a time remote from insertion.³ Only five of the 55 reported cases describe tamponade occurring within 30 min of central venous cannulation.⁴ These are two such acute cases which presented close to the time of cannulation and directly implicate introducer-dilator systems in the aetiology of ventricular perforation. Immediate recognition and rapid surgical intervention may result in patient salvage.⁸ As patient #1 was undergoing cardiac surgery the tamponade was directly visualised and the clot rapidly evacuated. When tamponade develops many hours after insertion, diagnosis and intervention is often delayed.⁹ The subclavian and jugular routes have both been implicated with respect to this complication.³ In the second

case described, cardiac rupture occurred despite placement of the wire in the femoral vein. The conclusion drawn was that as the introducer-dilator was railroaded over the wire, the wire buckled and the rigid combination of wire, introducer and dilator passed into the heart (instead of down the inferior vena cava) thereby producing fatal cardiac perforation.

In order to reduce the mortality associated with this complication, a high index of suspicion is mandatory if any clinical deterioration occurs in a patient with a central venous cannula in situ. The classical triad of hypotension, tachycardia and elevated filling pressures may be incomplete⁶ as was the case in our first patient: the nitrate infusion may have contributed to the low filling pressures noted.

Long dilators found in central venous cannulation kits have not hitherto been described in association with heart perforation. The dilators in the cases described were 23 and 70 cm in length respectively. In the case of the PA introducer-dilator, this dilator length (23 cm) represents 9 cm in excess of the introducer itself. These lengths diverge considerably from current recommendations for maximum central venous cannula length (15–16 cm).⁷ Superior vena caval (SVC) length has been studied and whilst it has been found to correlate with patient size, it is usually of the order of 3–10 cm.⁷ Figure 1 illustrates the possibility of placing the dilator tip in a cadaveric right ventricle using the wire-introducer technique when the dilator is inserted to its full extent. Estimation of SVC length in clinical practice does not always take into account the influence of Trendelenburg tilt which may produce cephalad shift of the heart.

We have described two cases of ventricular perforation implicating long dilators. Dilators have not previously been implicated in those cases of tamponade described in the literature which presented within two hours of the cannulation procedure.⁴

We suggest that central venous dilator length should be revised. Aspects of insertion technique should also be reviewed. Even though we avoided introducing the full length of the dilator in our first patient, this did not prevent perforation. In addition, radiological confirmation of guidewire position did not prevent cardiac perforation in the second case described. We would recommend that screening is continued during dilator insertion over the wire. We have observed that despite recommendations to the contrary¹⁰ in our own institution many practitioners insert dilators to their full extent. As Figure 1 illustrates, this practice, even without Trendelenburg tilt, may result in intraventricular position of the catheter tip and/or perforation.

FIGURE 1 Cadaveric reproduction of the events described in Case 1. The chest is open and the right subclavian vein has been cannulated using the guidewire-introducer technique under direct vision. The Braun Intradyn PA introducer is *in situ* and the dilator has not been removed. The opened right ventricle reveals the tip of the dilator lying within its cavity even without the influence of Trendelenburg tilt.

References

- 1 Krog M, Berggren L, Brodin M, Wickbom G. Pericardial tamponade caused by central venous catheters. *World J Surg* 1982; 6: 138–43.
- 2 Shah KB, Rao TLK, Laughlin S, El-Etr AA. A review of pulmonary artery catheterization in 6,245 patients. *Anesthesiology* 1984; 61: 271–5.
- 3 Delfalque RJ, Campbell C. Cardiac tamponade from central venous catheters. *Anesthesiology* 1979; 50: 249–52.
- 4 Collier PE, Ryan JJ, Diamond DL. Cardiac tamponade from central venous catheters. Report of a case and review of the English literature. *Angiology* 1984; 35: 595–600.

- 5 *Stengqvist O, Curelaru I, Linder L-E, Gustavsson B.* Stiffness of central venous catheters. *Acta Anaesthesiol Scand* 1983; 27: 153-7.
- 6 *Greenall M J, Blewitt RW, McMahon MJ.* Cardiac tamponade and central venous catheters. *BMJ* 1975; 2: 595-7.
- 7 *Mc Gee WT, Ackerman BL, Rouben LR, Prasad VM, Bandi V, Mallory DL.* Accurate placement of central venous catheters; a prospective, randomized, multicentre trial. *Crit Care Med* 1993; 21: 1118-23.
- 8 *Brandt RL, Foley WJ, Fink GH, Regan WJ.* Mechanism of perforation of the heart with the production of hydropericardium by a venous catheter and its prevention. *Am J Surg* 1970; 119: 311-6.
- 9 *Sheep RE, Guiney WB Jr.* Fatal cardiac tamponade. Occurrence with other complications after left internal jugular vein catheterization. *JAMA* 1982; 248: 1632-5.
- 10 *Hug CC Jr.* Monitoring. *In:* Miller RD (Ed.). *Anaesthesia*, 2nd ed. New York: Churchill Livingstone Inc., 1986: 448.