J Forensic Sci, Mar. 2003, Vol. 48, No. 2
Paper ID JFS2002071_482
Available online at: www.astm.org

CASE REPORT

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Iatrogenic Catheter-Related Cardiac Tamponade: A Case Report of Fatal Hydropericardium Following Subcutaneous Implantation of a Chemotherapeutic Injection Port*

ABSTRACT: The need to obtain dependable access to the vascular system constitutes a significant component in the treatment and management of critically ill patients. Intravenous chemotherapy administered to cancer patients over an extended period of time often results in loss of peripheral vascular access due to vein sclerosis, "exhaustion" or tissue necrosis. Medical investigators have designed and steadily upgraded a variety of devices constructed to improve venous access for long-term utilization. As with the introduction of any foreign object into the body, each of these devices has complications which may be life threatening and occasionally fatal. We present an unusual case of iatrogenic acute hydropericardium and cardiac tamponade caused by the percutaneous infusion of chemotherapeutic fluid via a right subclavian central venous implant system (Port-a-Cath®). Failure to implant and monitor the device with a radiograph following placement according to manufacturer's guidelines and accepted standards of medical practice were causally related to an unusual complication, namely, perforation of the right cardiac ventricle by the catheter tip, resulting in sudden and unexpected cardiac death.

KEYWORDS: forensic science, forensic pathology, central venous catheter, adverse effect, fatal hydropericardium, cardiac tamponade, and iatrogenesis.

Dependable long-term vascular access is warranted in chemotherapy for various modalities of treatment in patients with cancer and a variety of autoimmune or rheumatologic diseases. Extensive, prolonged intravenous therapy commonly results in loss of peripheral vascular access due to vein sclerosis or tissue necrosis and requires a more reliable mode of central venous access. Central venous catheters are widely used as a means of administering fluids, blood products, medications, and hyperalimentation in addition to monitoring the central venous pressure (1). Numerous well-recognized risks are associated with the use of central venous catheters. Among the most common are pneumothorax, hemothorax, hydrothorax, air embolism, catheter embolism, perforation of vein or heart, catheter sepsis, thrombophlebitis, bleeding diathesis, and cardiac arrhythmias (1–3). A potentially fatal yet uncommon risk of central venous catheters is cardiac tamponade. This kind of post-procedural complication has occurred up to 37 days after central venous catheter insertion and accounts for approximately 65% mortality (4). This clinically serious and potentially fatal condition must be considered in any patient who has unexplained hypotension anytime after placement of a central venous catheter. These risky outcomes typically are related to the operative insertion of the catheter or to the ultimate location of its tip. Immediate post-procedural chest roentgenographs are regarded as standard practice to both rule out any form of acute complication and confirm the appropriate position of the catheter tip.

We present the unique case of a 55-year-old woman who developed iatrogenic acute hydropericardium and subsequent rapidly ensuing cardiac tamponade after percutaneous infusion of a chemotherapeutic fluid via a subcutaneously placed right subclavian central venous implant system. Requiring chemotherapy for colon cancer treatment, she underwent placement of a Port-A-Cath® (Implantofix system). A post-insertion chest roentgenograph was not obtained. Five days after implantation of the central venous system and during administration of a chemotherapeutic agent at the oncologist's office, she experienced acute left neck and throat pain and suddenly deteriorated. She succumbed two hours after the initiation of the chemotherapy despite prolonged advanced cardiopulmonary resuscitation.

Postmortem examination confirmed a large hydropericardium (225 mL) leading to a fatal acute cardiac tamponade. The distal tip of the catheter perforated the apex of the relatively thin-walled right cardiac ventricle and advanced into the pericardial space. Microscopical examination of the right ventricular wall revealed inflammatory changes consistent with progressive centrifugal

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*Presented (Poster) at the 49th Annual Meeting of the American Academy of Forensic Sciences, February 1997, New York, N.Y.
Received 15 Feb. 2002; and in revised form 3 Oct. 2002; accepted 16 Nov. 2002; published 12 Feb. 2003.

tunneling of the catheter tip resulting in perforation. The mechanism producing the hydropericardium as well as the associated gross and microscopic cardiovascular findings will be discussed.

Case History

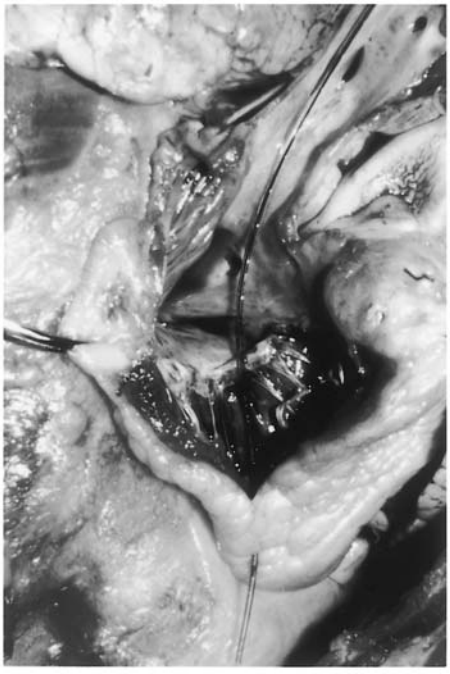
A 55-year-old female with infiltrating moderately differentiated colonic adenocarcinoma extending to the epicolic fat with local metastasis to one of seven pericolic lymph nodes (Stage T3N1M0) underwent a celiotomy with distal ileectomy, subtotal right ascending colectomy, ileocolostomy, and regional pericolic lipectomy/lymphadenectomy. One month after this operation, she began chemotherapy consisting of intravenous 5-Fluorouracil (5-FU), Leucovorin, dexamethasone, and Ativan with subsequent intravenous 5-FU administration one month later. Due to prospective prolonged intravenous chemotherapy, a right subclavian Port-A-Cath® (Implantofix system) was percutaneously inserted three months after the operation. A postoperative roentgenograph of the chest after implantation of the injection port and catheter was not obtained.

The patient underwent the third course of 5-FU chemotherapy with normal saline via the Port-a-Cath® system over a two-hour period on the same day as the Port-a-Cath® placement. She complained of "considerable pain from the right side" upon arrival at the oncologist's office before the chemotherapy infusion, which the clinician treated by an intramuscular injection of 10 mg morphine sulfate. Three days later the patient complained of substernal chest pain to family members, prompting an appointment with her general practitioner six days after the Port-a-Cath® placement. The source of pain was not identified. She returned to her oncologist's office eight days after the Port-a-Cath® placement for the second instillation of chemotherapeutic agents via the new port. Fifty minutes after the initiation of the infusion, which consisted of 500 mg 5-FU mixed in 500 mL normal saline, the patient complained of "fullness in the throat and left neck pain" for which she was given sublingual nitroglycerin. Fifteen minutes later she was noted to be "clammy, diaphoretic, and weak" with intermittent choreiform movements of all extremities, associated with Kussmaul respirations, frothing at the mouth, and eyes "rolling in their sockets." She was moaning but responsive to name. Diazepam was administered intravenously. She was transferred by wheelchair to the nearby Emergency Department where she was observed to be bradycardic. Cardiopulmonary resuscitative measures were initiated. The bradycardia persisted and deteriorated to an irregular rhythm noted by an emergently placed percutaneous venous cardiac pacemaker. She was pronounced dead less than two hours after commencing the 5-FU infusion via the Port-a-Cath system®.

In addition to the colonic adenocarcinoma, significant past medical history included systemic hypertension, coronary artery disease with intermittent angina pectoris, Type II insulin-dependent diabetes mellitus, and chronic anxiety.

Autopsy Findings

The decedent was a well-developed, well-nourished Caucasian female measuring 5 ft-2 in. and weighing 155 lb. A healing, transverse cutaneous surgical incision overlying the Port-a-Cath® infusion port was present at the lateral right subclavian chest. The subcutaneously placed venous implant system, consisting of a portal housing, catheter lock, and plastic catheter, was intact. The catheter coursed superiorly to the medial right infraclavicular soft tissues, at which point it entered into the right subclavian vein. Upon entry into the venous lumen, it extended in an antegrade fashion through the subclavian vein to the superior vena cava and through the right cardiac atrium and right ventricle. The catheter perforated the anteromedial apex of the right ventricle with its distal portion extending 1¼ in. beyond the epicardial fat (Figs. 1*a* and 1*b*). The pericardial sac was massively distended and contained 225 mL of clear liquid with a slight light brown tinge. Hemopericardium was not identified. Within the right atrium a thin superficial subendocardial tear was adjacent to the margin



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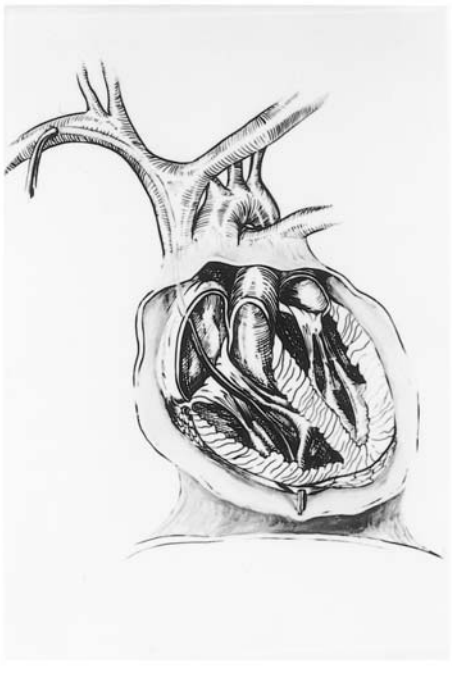

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FIG. 1a—*In situ dissection of the cardiac right atrium and ventricle illustrating the Catheter passing through the cardiac chambers and perforating the apex of the right atrium.* b—*Drawing of the same.*

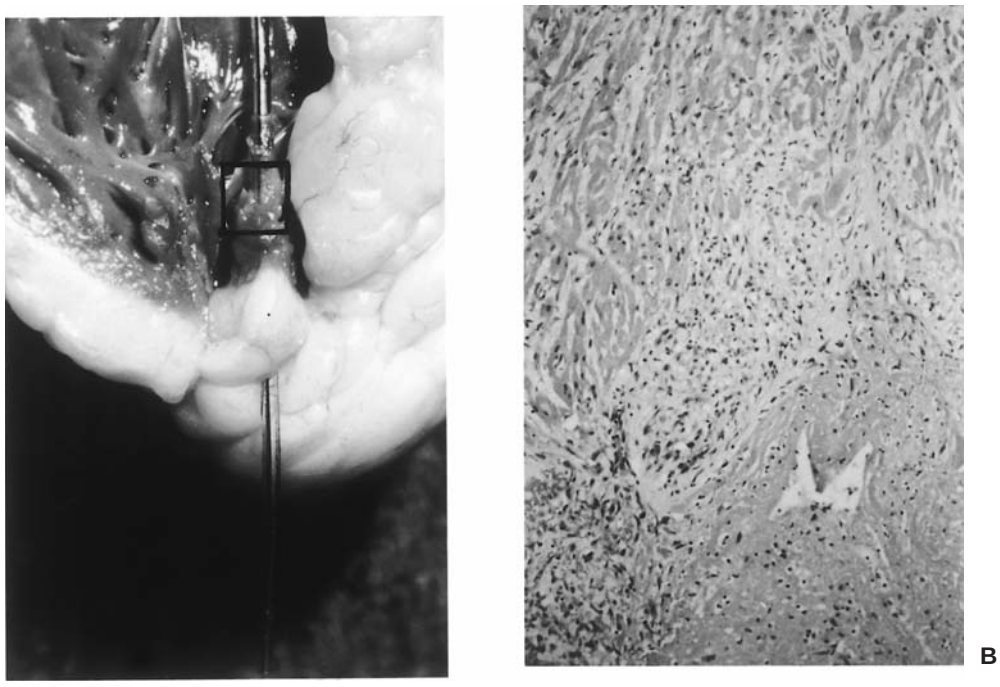

FIG. 2a—*Close-up view of the anteromedial right apex with catheter perforation site. Coned area for microscopic examination.* b—*Microscopic view of the perforation site exhibiting dense myofiber coagulative necrosis and early granulation tissue formation.*

of the coronary sinus. The entire length of the catheter measured 14 in. from the tip to the point of egress at the port of the receptacle.

Other significant autopsy findings included mild cardiomegaly (325 g) with concentric left ventricular myocardial hypertrophy and mild atherosclerosis of the aorta. There was evidence of a healing subtotal colectomy/distal ileectomy with an intact ileocolostomy. No residual tumor or metastasis was present at necropsy. Postmortem toxicology was negative.

Microscopical examination of the endomyocardium adjacent to the catheter tip revealed organized fibrin deposition with a mixed inflammatory infiltrate (Figs. 2*a* and 2*b*). Similar infiltration with granulation tissue involved the myocardium at the perforation site.

The cause of death was attributed to cardiac tamponade from an acute hydropericardium due to the percutaneous infusion of chemotherapeutic fluid via the right subclavian venous implant system (Port-a-Cath®) due to delayed perforation of the right ventricle by the catheter tip.

Discussion

Although the attainment of a long-term vascular access system may facilitate chemotherapy in cancer and other patients needing prolonged intravenous therapy, numerous risks are associated with both the placement of the central venous catheter and the presence of a foreign object within the body. Immediate complications after the insertion may include pneumothorax, hemothorax, and air embolism. Delayed complications most frequently present as catheter-related sepsis, thrombophlebitis, venous or intracardiac thrombosis, pulmonary thromboembolism, and migration of the catheter tip. Cardiac tamponade resulting directly from cardiac perforation is a rare and potentially fatal sequela of central venous catheter placement.

Turner and Sommers initially reported a case in 1954 in which a polyethylene catheter disappeared from the right median cubital vein and embolized to perforate the right atrium (5). In 1956, Brown and Kent reported a similar case of cardiac tamponade resulting from right ventricular perforation after a polyethylene catheter migrated from the femoral vein to the heart (6). Friedman and Jurgeleit reported in 1968 the first non-embolic hydropericardium arising from right atrial perforation by a polyethylene catheter used to monitor central venous pressure (7). Since then, over 100 cases have been reported in the literature of cardiac tamponade caused by central venous catheter placement (8). Various investigators have shown that tamponade may occur days to weeks after the insertion of the catheter and carries an approximate 65% mortality rate (4).

In 1989, the Food and Drug Administration (FDA) established firm guidelines regarding catheter tip location: "Except for pulmonary artery catheters, the catheter tip should not be placed in, or allowed to migrate into, the heart. Catheter tip position should be confirmed by radiograph or other imaging modality and be rechecked periodically" (9). Optimally, the catheter tip should be placed at the junction of the superior vena cava and the right atrium, visualized radiographically in the superior vena cava two centimeters proximal to the pericardial reflection (8). Minor proximal migration of the catheter tip coupled with neck movements initiating subsequent endothelial irritation has been proposed as a predisposing factor for cardiac perforation. In a study using newborn infants, Fischer et al. reported that catheter tips moved 5 to 6 cm toward the heart with extension and lateral flexion of the neck. The tip advanced 2 to 3 cm toward the heart with lateral neck flexion causing perforation of the atrial or venous wall with 60% frequency among cadaveric infants (10). Chabanier et al. reviewed 67 cases involving myocardial perforation ascribed to central venous catheter placement, all of which were derived from incidents reported in the medical literature between 1968 and 1988 (11). Of those cases where the actual site of perforation was identified, 29 cases involved the right atrium, 18 the right ventricle, and 3 the superior vena cava.

The Port-a-Cath® was initially introduced for infusion chemotherapy in 1984 and has gained acceptance as a safe and reliable means of administering intravenous hyperalimentation and chemotherapy on a long-term basis (12). An implanted venous access device such as the Port-a-Cath® reduces the risk of catheter-related sepsis and thrombosis and is desirable for its cosmetic appearance (12,13). Poorter et al. retrospectively studied the peri-operative and post-operative complications arising from the implantation of 169 Port-a-Cath® venous access devices over a six-year period (12). They found that peri-operative and post-operative complications occurred in 11.9% of the patients, as follows: pneumothorax, hematoma, and infection. The catheter tip was placed in the right atrium in two cases and was subsequently pulled back into the superior vena cava without complications. During infusion of chemotherapy, three patients experienced extravascular migration of the catheter, causing perivascular fluid extravasation. In none of these cases did cardiac perforation occur. In Poorter's study, initiation of chemotherapy after implantation of the Port-a-Cath® was approximately 10–14 days. The patient in our case study began her chemotherapeutic regimen on the same day as the implantation of her Port-a-Cath®. Similarly, Barrios et al. evaluated complications associated with Port-a-Cath® placement in 218 patients over a three-year period (14). Pneumothorax, soft tissue infection, catheter occlusion and venous thrombosis occurred in only 10% of the patients. The catheter became detached from the subcutaneous port in two patients, subsequently migrated, and embolized into the right atrium. Although the catheters migrated to the right atrium, no perforation of the heart occurred. The patients were asymptomatic, and the catheters were removed surgically without complications. Long-term Silastic catheters, such as the Hickman, Broviac and Port-a-Cath®, are more pliable compared to the short-term central venous catheters and consequently cause less frequent perforations of the heart (15). Notwithstanding the relative paucity of such complications, Kulvatunyou et al. reported a case of superior vena caval perforation from a Port-a-Cath® occurring three months after the insertion of the device (16). An anteroposterior chest radiograph revealed that the catheter tip was within the superior vena cava; yet an immediate follow-up contrast injection showed extravasation of contrast into the mediastinum. The case presented here is the first to describe right ventricular perforation causally related to misplacement of a Port-a-Cath®. Such a complication demonstrates that the long-term Port-a-Cath® has an equivalent potential for causing vascular and cardiac perforations as that of temporary indwelling central venous catheters.

Brandt et al. characterize the mechanism of cardiac and vascular perforation involving central venous catheters (Fig. 3). Catheter-induced endocardial injury leads to localized thrombus formation with subsequent tip adherence to the subjacent cardiac wall (17). Cardiac contraction concurrent with turbulent flow around the thrombus and the static catheter tip conduce to cause endocardial erosion. The silicone or Silastic central venous catheters are less injurious to the endovascular surfaces because they are less rigid than the non-Silastic catheters (8).

Cardiac tamponade must be considered in *any* patient with unexplained hypotension during central venous fluid administration. A high index of suspicion of cardiac compromise must exist whenever a patient with a long-term intravenous catheter experiences sudden and unexplained deterioration. Clinical manifestations include sudden onset of acral or mucosal cyanosis, apnea, grunting respirations, restlessness, confusion, nausea, and epigastric discomfort (2,18). Rapid evaluation of vital signs quickly facilitates recognition of the constellation of such complications. Prompt resuscitative measures must be taken as soon as this diagnosis is suspected. Infusion through the catheter must be immediately discontinued, and the infusate should be lowered below the patient in an attempt to empty the pericardial sac by gravity (4). Aspiration of the fluid through the catheter with subsequent removal of the catheter has also been proposed (2). Pericardiocentesis is indicated if any of the following features are present: cephalic or cervical venous distention, diminished heart sounds, Friedreich's sign (S_3), pulsus paradoxus, sharp x-descent in the pulse wave, or pulse pressure $<$20 mmHg (19,20). If pericardiocentensis is not effective in dissipating the signs of cardiac tamponade, an immediate pericardiotomy must be performed.

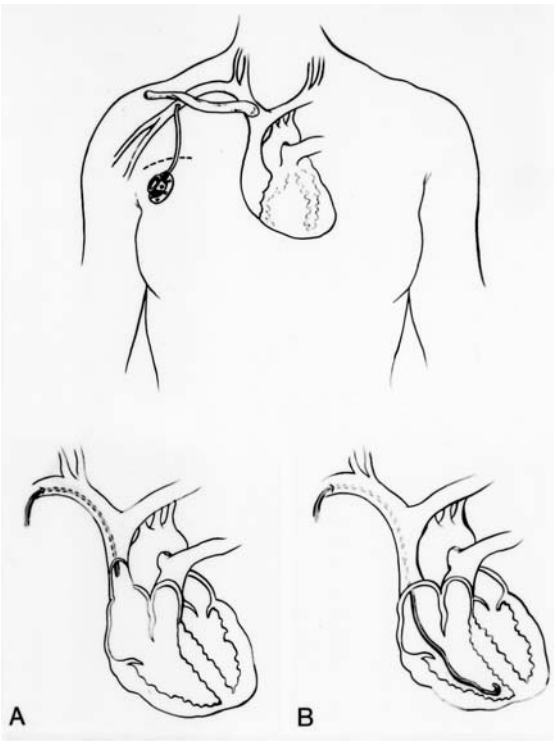

FIG. 3—*Illustration of Port-a-Cath® placement, right subclavian vein.* a—*Proper placement with tip in the distal superior vena cava.* b—*Tip within the right ventricle, a nidus for perforation complications.*

Conclusion

Although the placement of a central venous catheter may be imperative in the treatment of a critically ill patient, several risks are associated with both short-term catheters and long-term implanted venous access devices such as the Port-a-Cath®. Approximately three million central venous catheter procedures are performed annually in the United States (9). According to a medical device-reporting database, 52% of complications associated with central venous catheters are due to physician error (21). A chest roentgenograph is obligatory after the insertion of a central venous catheter to determine the location of the catheter tip and to visualize any unwarranted trauma. The patient in this case report did not undergo a post-procedural chest roentgenograph, a deviation from this unequivocal operative standard of care. Prompt repositioning must be undertaken if a timely and appropriately performed X-ray shows that the tip is not within the superior vena cava two centimeters proximal to the junction of the superior vena cava and right atrium. Cardiac tamponade secondary to cardiac perforation is a rare yet

life-threatening complication of central venous catheter placement. Patients with indwelling central venous catheters must be continually observed for clinical signs and symptoms that may indicate cardiac tamponade or any other complication described above.

Acknowledgment

The illustrations were provided by Dennis L. Parrish, medical illustrator.

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