

Swan-Ganz Pulmonary Artery Catheterization–Safe But Not Harmless

Stefanie Keymel¹ and Stephan Steiner^{2*}

¹Department of Medicine, Division of Cardiology, Pneumology and Angiology, University Hospital Duesseldorf, Duesseldorf, Germany

²Department of Medicine, Division of Cardiology, Pneumology and Intensive Care Medicine, St. Vincenz Hospital, Limburg, Germany

***Corresponding Author:** Stephan Steiner, Department of Medicine, Division of Cardiology, Pneumology and Intensive Care Medicine, St. Vincenz Hospital, Limburg, Germany.

Received: February 13, 2016; **Published:** February 18, 2016

Introduction

Swan-Ganz catheter is widely used for the diagnosis of pulmonary hypertension as well as hemo-dynamic monitoring in intensive care medicine or perioperative management since its inauguration in 1970. Complications can be related to the venous access site, to the catheterization, to stay of the catheter or to the removal of the catheter (Table 1). In patients with pulmonary hypertension defined by a mean pulmonary artery pressure of 25 mmHg or higher, fatal complications occur in less than 0.06% [1]. Despite the fact, that these seems to be a very low rate, it should be mentioned, that all of the examinations were done elective and the patients were classified to be hemodynamically stable before the procedure [1]. In contrast, complication rates of serious events are reported in up to 4.4% in critical ill patients [2-4].

Access Site

Normally, most of the Swan Ganz catheters are inserted using an intravenous sheath (5 to 7 ch). Therefore physicians should be aware of complications associated with venous puncture, e.g. bleeding, arterio-venous fistula or arterial laceration. In a prospective analysis, Hoepfer, *et al.* found serious adverse events related to the venous access in about 0.5% [1]. In this study, venous access site was the internal jugular vein in nearly 75% of the cases. Therefore complications might vary beyond different approaches. Vena subclavia or jugularis access, which are often used by intensive care physicians might be complicated by pneumothorax or laceration of arteria carotis.

Catheterization

During catheterization dysrhythmias, knitting of the catheter or ventricular perforation and pulmonary haemorrhage as life-threatening conditions need to be considered as serious complications.

Dysrhythmias

When advancing the catheter often premature atrial or ventricular beats are triggered. Shah, *et al.* found premature beats in approximately two thirds of the patients [4]. More serious cardiac arrhythmias include ventricular tachycardia or ventricular fibrillation or right bundle branch block in the presence of left bundle branch block resulting in a total heart block. Boyd, *et al.* report the occurrence of ventricular tachycardia in 1.5% of patients who received the catheter for perioperative management [2]. Hoepfer, *et al.* report only 3 ventricular tachycardias in 7200 right heart catheter procedures for the evaluation of pulmonary hypertension [1]. The rate of occurrence of a bundle branch block seems to be rather low with 4 cases of 6245 perioperative right heart catheters or 1 of 7200 diagnostic right heart catheters [1,4]. Both, ventricular tachycardias and bundle branch blocks may be resolved by catheter removal or may need further specific treatment. Other authors who focus on critical care patients report much higher incidences on catheter associated arrhythmias which were detected in 25-68% [5,6]. Interestingly, most of the arrhythmia did not require specific therapy. Incidence of severe arrhythmia might be reduced by adjusting patients in the head-up and right lateral position while passing the catheter [7].

Related to access	Multiple sticks
	Arterial puncture
	Arteriovenous fistula
	Hematoma
	Pneumothorax
	Air embolism
	Vagal reaction
	Local infection
Catheterization	Looping / Knitting of the catheter
	Atrial or ventricular premature contractions
	Ventricular tachycardia / ventricular fibrillation
	Right bundle branch block
	Total heart block in pre-existing left bundle branch block
	Valve rupture
	Ventricular perforation
	Pulmonary hemorrhage
Stay of the catheter	Pulmonary infarction
	Thrombosis / pulmonary embolism
	Endocarditis
	Sepsis

Table 1: Complications of right heart catheterization.

Knotting of the Catheter

Over the last decades there were several case reports on knotting of the Swan Ganz catheter as a result of intraventricular looping. In most of the cases, removal of the knotted catheter by interventional techniques was possible. Techniques vary between tightening the knot as much as possible in order to remove it to the sheet, the use of Loop snares or even the use of biopsy forceps [8]. If the catheter could be retired, it might become necessary to convert access site to a controlled venotomy to aid removal. Nevertheless, if the catheter is fixed in the heart, for example within the range of tricuspidal or pulmonary valve, surgery might be mandatory [9].

Ventricular Perforation

Ventricular perforation is a rare but life threatening complication of right heart catheterization. Ventricular perforation results in cardiac tamponade resulting in a cardiogenic shock [3] requiring rapid treatment by operation or puncture. Perforation of the RV may not be apparent during open heart surgery [10]. As predisposing factors for ventricular perforation during catheterization a small chamber size, stiff catheter, outflow tract obstruction, and myocardial infarction are discussed. The perforating potential of PA catheters is increased by cooling and by the presence of multiple lumens, as in the case of central venous catheters [10]. Inflation of the balloon reduces the risk of RV perforation.

Pulmonary Artery Injury

Pulmonary artery injury occurs in 0.03%-0.47% [2,11-13]. Pulmonary artery injury is a severe, life threatening complication with high mortality of more than 50% [11-12]. Therefore, cardiologists and intensive care physicians should be aware of the symptoms of pulmonary artery injury and should define potential treatment strategies.

The risk of pulmonary artery rupture by Swan-Ganz catheterization has been shown to be determined by diverse factors including advanced age, female sex, comorbidities, medication as well as the handling during catheterization (Table 2) [3,11,12,14]. Further, a large pressure gradient across the balloon leads to wedging in a more peripheral position of the balloon [15]. As critical medications, corticoids and oral anticoagulation have to be mentioned [16]. In order to reduce the risk of catheter induced injury proper catheter placement and management is essential (Table 2). Also, awareness of this complication is essential for the efficient management. The leading symptom is hemoptysis that may occur immediately after deflation of the catheter or during the later course due to rupture of a false aneurysm (PAFA). Other symptoms include respiratory insufficiency potentially leading to asphyxia and hypovolemic shock. Asymptomatic PAFA may be discovered by chest radiographs.

Patient characteristics	Age > 60 years
	Female sex
Comorbidities	Pulmonary hypertension
	Coagulation disorders
Medication	Systemic anticoagulation
	Long-term steroid use
Handling	Excessive catheter manipulation
	Balloon hyperinflation
	Inflation of the catheter balloon with fluids other than air
Others	Surgically induced hypothermia
	Cardiac decompression
	Cardiac manipulation during surgery

Table 2: Risk factors for pulmonary hemorrhage after Swan-Ganz catheterization [3,11,12,14].

In view of the low incidence and the lack of controlled studies, there is no gold standard in treatment of pulmonary vascular rupture or false aneurysm. Treatment strategies vary between watchful waiting [15], surgical therapy [14,18] or interventional therapy. In the literature, the majority of interventional therapy is angiographic embolization [16,20]. Stent graft placement has been reported in one previous case report, only, which was also successful for the acute treatment of relevant hemoptysis due to Swan-Ganz catheter induced pulmonary bleeding [21,22]. The treatment of a PAFA has to be tailored to the clinical condition of the patient as well as local conditions, e.g. the availability of interventional prospects and skills.

Besides general measures such as securing hemodynamic and respiratory functions as well as optimizing coagulation, it is recommended to leave the catheter in position with slight inflation of the balloon in order to block ante grade blood flow to the injured vessel. In patients who survive the initial hemoptysis, the formation of PAFA has been reported in about 25% of the patients within minutes or even months [2,13,17]. Although the formation of a PAFA prevents extravasation and further pulmonary bleeding, it might contribute to recurrent hemorrhage in 30-40% leading to death in 40-70% [17,22]. The risk of recurrent bleeding results from the instability of the PAFA which is not surrounded by an endothelial layer as typical arterial false aneurysms but by compressed lung tissue. In the literature, a single case of complete resolution of a PAFA without specific treatment has been described [17]. However, due to the high risk of recurrent bleeding and the associated substantial mortality there is largely consent that a PAFA should be treated [13,23].

The aim of the initial specific treatment is the effective exclusion of the PAFA from the pulmonary vascular bed to avoid or stop the potentially life-threatening pulmonary bleeding. A surgical approach as the most invasive procedure should be considered in pulmonary bleeding occurring during an operation or in cases of a central false aneurysm or hemothorax [13,14,18]. Otherwise, an interventional approach is preferred due to its less invasive nature. Interventional treatment by embolization with coils or sponge material has been proven to be effective in the treatment of PAFA [16,20] and is considered as the treatment of choice for interventional therapy of a PAFA.

Also, local thrombin injection has been successfully applied [24]. In some cases, interventional treatment was performed by the implantation of covered stents with good results [24,22]. Therefore, stent implantation may be added to the repertoire of tools for the treatment of PAFAs and may become a suitable alternative – especially in the hand of interventional cardiologist.

Stay of the Catheter

The longer the catheter is inserted, the higher is the risk of infection or thrombosis [25,26]. Therefore these problems mainly occur in critical ill patients at the ICU. It could be estimated, that catheter associated infections occur in 1.7-13% [2,27,28,]. Based on autopsy cases, incidence of mural thrombi has been reported between of 33%-61% [26].

In summary, Swan- Ganz catheterization is safe but might be associated with severe adverse events. Most of the complications could be prevented by adequate training of the physician. Furthermore, the ability to interpret the obtained data [9] is a basic requirement for a responsible use of Swan- Ganz catheterization. Therefore PAC insertion should be coupled to a defined treatment protocol with proven efficiency [29].

Bibliography

1. Hoepfer MM., et al. "Complication of right heart catheterization procedures in patients with pulmonary hypertension in experienced centers". *Journal of the American College of Cardiology* 48.12 (2006): 2546-2552.
2. Boyd KD., et al. "A prospective study of complications of pulmonary artery catheterizations in 500 consecutive patients". *Chest* 84.3 (1983): 245-249.
3. Bossert T., et al. "Swan-Ganz catheter-induced severe complications in cardiac surgery: right ventricular perforation, knotting, and rupture of a pulmonary artery". *Journal of Cardiac Surgery* 21.3 (2006): 292-295.
4. Shah KB., et al. "A review of pulmonary artery catheterization in 6,245 patients". *Anesthesiology* 61.3 (1984): 271-275.
5. Iberti TJ., et al. "Ventricular arrhythmias during pulmonary artery catheterization in the intensive care unit. A Prospective study". *American Journal of Medicine* 78.3 (1985): 451-454.
6. Sprung CL., et al. "Ventricular arrhythmia during Swan Ganz catheterization of the critically ill". *Chest* 79.4 (1981): 413-415.
7. Pipanmekaporn T., et al. "Impact of patients' positions on the incidence of arrhythmias during pulmonary artery catheterization". *Journal of Cardiothoracic and Vascular Anesthesia* 26.3 (2012): 391-394.
8. Georghiou GP., et al. "Knotting of a pulmonary artery catheter in the superior vena cava: surgical removal and a word of caution". *Heart* 90.5 (2004): 1-2.
9. Bagul NB., et al. "Knot in the cava- an unusual complication of Swan- Ganz catheters". *European Journal of Vascular and Endovascular Surgery* 29.6 (2005): 651-653.
10. Lyew MA., et al. "Right ventricular perforation by a pulmonary artery catheter during coronary artery bypass surgery". *Anesthesia & Analgesia* 82.5 (1996): 1089-1089.
11. DeLima LG., et al. "Catheter-induced pulmonary artery false aneurysm and rupture: case report and review". *Journal of Cardiothoracic and Vascular Anesthesia* 8.1 (1994): 70-75.
12. Kearney TJ., et al. "Pulmonary artery rupture associated with the Swan-Ganz catheter". *Chest* 108.5 (1995): 1349-1352.
13. Sirivella S., et al. "Management of catheter-induced pulmonary artery perforation: a rare complication in cardiovascular operations". *Annals of Thoracic Surgery* 72.6 (2001): 2056-2059.
14. Kelly TF Jr., et al. "Perforation of the pulmonary artery with Swan-Ganz catheters: diagnosis and surgical management". *Annals of Surgery* 193.6 (1981): 686-692.
15. Pape LA., et al. "Fatal pulmonary hemorrhage after use of the flow-directed balloon-tipped catheter". *Annals of Internal Medicine* 90.3 (1979): 344-347.
16. Poplousky MR., et al. "Swan-Ganz catheter-induced pulmonary artery pseudoaneurysm formation: three case reports and a review of the literature". *Chest* 120.6 (2001): 2105-2111.

17. You CK and Whatley GS. “Swan-Ganz catheter-induced pulmonary artery pseudoaneurysm: a case of complete resolution without intervention”. *Canadian Journal of Surgery* 37.5 (1994): 420-424.
18. Deren MM., *et al.* “Perforation of the pulmonary artery requiring pneumonectomy after the use of a flow-directed (Swan-Ganz) catheter”. *Thorax* 34.4 (1979): 550-553.
19. Lafita V., *et al.* “Pulmonary artery pseudoaneurysm: etiology, presentation, diagnosis, and treatment”. *Seminars in Interventional Radiology* 24.1 (2007): 119-123.
20. Ferretti GR., *et al.* “False aneurysm of the pulmonary artery induced by a Swan-Ganz catheter: clinical presentation and radiologic management”. *American Journal of Roentgenology* 167.4 (1996): 941-945.
21. Zuffi A., *et al.* “Swan-Ganz-induced pulmonary artery rupture: management with stent graft implantation”. *Catheterization and Cardiovascular Interventions* 76.4 (2010): 578-581.
22. Keymel S., *et al.* “Stenting as a rescue treatment of a pulmonary artery false aneurysm caused by Swan-Ganz catheterization”. *Case Reports in Pulmonology* (2014).
23. Dieden JD., *et al.* “Pulmonary artery false aneurysms secondary to Swan-Ganz pulmonary artery catheters”. *American Journal of Roentgenology* 149.5 (1987): 901-906.
24. Dobies DR., *et al.* “Images in cardiovascular medicine. Repair of a perforated pulmonary artery due to a Swan-Ganz catheter using thrombin injection”. *Circulation* 119.17 (2009): e521-e522.
25. Sise MJ., *et al.* “Complications of the flow -directed pulmonary artery catheter: a prospective analysis in 219 patients”. *Critical Care Medicine* 9 (1981): 315-318.
26. Lange HW., *et al.* “Local complications associated with indwelling swan-Ganz catheters: autopsy study of 36 cases”. *American Journal of Cardiology* 52.8 (1983): 1108-1111.
27. Elliot CG., *et al.* “Complications of pulmonary artery catheterization in the care of critical ill patients. A prospective study”. *Chest* 76.6 (1979): 647-652.
28. Rosenwasser RH., *et al.* “Complications of Swan-Ganz catheterization for hemodynamic monitoring in patients with subarachnoid hemorrhage”. *Neurosurgery* 37.5 (1995): 872-876.
29. Hadian M and Pinsky MR. “Evidence-based review of the use of the pulmonary artery catheter: impact data and complications”. *Critical Care* 10.8 (2006): 1-11.

Volume 2 issue 1 February 2016

© All rights are reserved by Stefanie Keymel and Stephan Steiner.