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Mobility and Ambulation for Patients with Pulmonary Artery Catheters: A Retrospective Descriptive Study

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Abstract

Purpose—The purposes of this retrospective study are to: 1) describe the amount and type of documented mobility activity for patients with an indwelling Pulmonary Artery Catheter (PAC) and 2) document the frequency and type of complications that occur with an indwelling PAC during patient participation in these activities.

Methods—This study is a single-center, retrospective, descriptive study including all patients (>18 years) between June 2010 and October 2012 with an indwelling PAC in the Cardiology Intensive Care Unit (CICU). Data was extracted on all documented mobility activity each of these patients performed with nursing or during skilled treatments provided by a physical therapist (PT), or occupational therapist (OT). Any notation of PAC-related complications while the PAC was in place was recorded.

Results—In the CICU over a 29-month period, 366 patients with indwelling PACs performed bed mobility, transfers, ambulation and climbed stairs with no reports of PAC complications during or in relation to participation in mobility activity.

Conclusion—The data suggests that participation in mobility activities does not place patients with an indwelling PAC at increased risk of PAC related complications. This data further supports the involvement of rehabilitation specialists in the CICU. Future prospective research is necessary to measure the effects of physical therapy treatment on patients with indwelling PAC.

Introduction

Use of the Pulmonary Artery Catheter (PAC), an indwelling catheter for continuous hemodynamic monitoring, was first reported in the intensive care unit (ICU) in the 1970s.¹ The PAC “allow(s) measurement of hemodynamic variables that cannot be measured reliably or continuously by less invasive means.”² The PAC is inserted through the right intra-jugular or, less commonly, the left subclavian or femoral veins. Once inserted, it remains in the pulmonary artery, providing continuous hemodynamic monitoring.³ Common indications for use of a PAC include management of shock, intravascular volume, response to therapeutic intervention, and monitoring of hemodynamic parameters for determining candidacy for receipt of a heart transplant.^{2,4}

Patients with PACs are monitored closely in an ICU setting. Due to the risk of potential complications, common practice is to reevaluate the medical necessity of ongoing PAC use daily, and to remove the PAC as soon as medically appropriate.² Potential complications related to PAC insertion include ventricular arrhythmias, right bundle branch block (which if combined with preexisting left bundle branch block will cause complete heart block), pneumothorax, or knotting of the catheter. Potential complications with ongoing use of a PAC include pulmonary artery infarction from the PAC being left in contact with the pulmonary artery, pulmonary artery rupture (most commonly due to over inflation of the balloon), or line infection.⁵ Finally, it has been suggested that potential complications from positional changes with an indwelling PAC include catheter fracture, movement within the pulmonary artery causing injury to the vessel or accidental dislodgment into the right ventricle, dysrhythmias, and infarction or rupture of pulmonary artery.⁶ This suggestion, however, has not been addressed with an evidence-based approach.

Concerns about potential complications from positional changes with an indwelling PAC are important to address as early mobilization and the provision of appropriately-timed skilled physical therapy for patients in the ICU are emerging areas of research and practice. There is increasing awareness of the many negative effects of prolonged bedrest, including muscle atrophy, pressure ulcers, pneumonia, decreased insulin sensitivity, and decreased aerobic capacity (for review see Winkelman)⁷. Evidence supports physical therapy treatment and early mobility as a safe and effective intervention for patients in an ICU (for review see Adler et al)⁸, even for those receiving extracorporeal membrane oxygenation.⁹ Recent evidence also shows that physical therapy intervention in the medical ICU helps more patients return to independent functional status than standard ICU care alone¹⁰ and reduces ICU and hospital length of stay.¹¹ Patients with PACs were not excluded from either study.

The actual risk of potential PAC complications arising from positional changes or body movement is not known, as there are no published reports directly measuring the effects of positional changes and body movement on PAC placement or complications. Related studies include exercise research studies where PACs were used to measure hemodynamic stability and exercise response as subjects: sat, marched in place, transferred to a bedside chair, ambulated, climbed stairs and completed exercises stress tests, all without PAC complications reported.^{12–16} Expert opinion regarding the relationship between patient activity and PAC dysfunction states “although no specific report has been published about

the safety of sitting or walking ICU patients who have pulmonary artery catheters, the literature does appear to support both the feasibility and safety in practice.”⁶ Finally there have been similar concerns about potential complications caused by changes in position and mobility activities with femoral artery catheters. A retrospective case series reported that no adverse events were documented in physical therapy sessions in which patients with femoral arterial catheters performed mobility activities including sitting edge of bed, standing, transferring to a chair, and walking.¹⁷ The study included only femoral arterial catheters and did not report on PACs.

To begin to explore the risk of PAC complications caused by positional changes and body movement, existing data was pulled from a quality improvement project tracking physical therapy practice for patients with an indwelling PAC and retrospectively assessed mobility activity and PAC-related complications. The purposes of this retrospective, descriptive study are to 1) describe the amount and type of documented mobility activity for patients with an indwelling PAC and 2) document the frequency and type of complications that occur with an indwelling PAC during patient participation in these activities.

Methods

Facility-Specific Practice

Prior to 2010, there was variable practice regarding the frequency of consults received by physical therapy for patients with indwelling PACs in our CICU. Variable practice in the ICU is a common finding in the literature^{18–21}. In the absence of a consensus policy or guideline on patient participation in mobility activity with an indwelling PAC, whether or not a patient was able to transfer out of bed or ambulate was left to the discretion of the individual health care provider, typically the nurse, physician and/or therapist. Personal views varied widely. In general, patients with PACs who were independent with mobility were allowed to transfer and move about in their room while patients with PACs in place who required assistance for mobility activities were inconsistently mobilized.

In discussion with clinical leadership and the quality improvement committee of the CICU, a plan was created for physical and occupational therapy evaluation and treatment of patients with indwelling PACs while monitoring closely for adverse events. A policy was created prior to June 2010 to address the variable access to mobility activities and physical therapy interventions for this patient population. Physical therapy and occupational therapy would continue to be consulted to evaluate and treat patients with indwelling PACs, but in order to complete mobility activities outside of the patient’s room a specific order from the attending physician was required and a registered nurse had to be present and monitoring the PAC waveform on a portable telemetry monitor at all times. For quality improvement purposes following the implementation of this policy, electronic nursing documentation was utilized to create a list of all patients who had a PAC placement from June 2010 to October 2012.

From June 2010 to October 2012, patients in the CICU were treated by approximately 25 PTs. The PTs in our facility are classified as cardiovascular clinical specialists, permanent staff members (who treat acute care and ICU cardiovascular patients), or rotating staff members (who rotate between acute care/ICU, acute rehabilitation, and outpatient practice).

Two of the 3 cardiovascular team clinical specialists have earned the board certification of Cardiovascular and Pulmonary Certified Specialist (CCS) from the American Board of Physical Therapy Specialties. They were responsible for supervising and consulting with PTs practicing in the CICU. Permanent (7) and rotating (14) PTs were all working toward or had completed specific competency checklists under the supervision of the clinical specialists.

This study is a single-center, retrospective, descriptive study completed at University Hospital in the University of Michigan Health System, an 800-bed teaching hospital in a suburban area. The University of Michigan Institutional Review Board approved this study. All patients in the 10-bed cardiology ICU (CICU), age 18 years or older, with an indwelling PAC placed between June 2010 and October 2012 were included in this study.

Data Extraction

The list of PAC placements from June 2010 to October 2012 included the patients' medical record numbers, PAC placement dates and times and PAC removal dates and times. Using the medical record number, each patient's electronic medical record was accessed to extract and record the following variables to describe the patient population, the amount and type of documented mobility activity, and the frequency and type of PAC complications. Data were recorded using REDCap software²² and summarized using SPSS Statistics, version 22 (IBM Corporation, Armonk, NY) and MATLAB (The Mathworks, Natick, MA) custom software programs.

Patient Characteristics

Data were extracted from physician notes including the admitting history and physical, daily progress notes, procedure notes, consults, alert notes and discharge summaries. Information extracted included: category of diagnosis (ventricular assist device/transplant workup, listed 1A or 1AE for transplant, heart failure, respiratory failure, renal failure, myocardial infarction, sepsis/endocarditis, cardiac arrest/arrhythmia/syncope, or PAC guided diuresis), age at admission (in years), gender (male or female), ejection fraction (less than 10 percent, 10–19 percent, 20–29 percent, 30–39 percent, 40–49 percent, greater than or equal to 50%, or unknown), and status at time of PAC removal (alive or deceased).

Mobility Data

Mobility data were extracted from physical therapy, occupational therapy and nursing documentation. From physical therapy documentation information was extracted to determine whether or not the patient performed each of the following activities (yes or no): rolling, supine to sit, sit to stand, bed to chair transfer, ambulation, and stairs. From occupational therapy documentation information was extracted to determine whether or not the patient performed each of the following activities (yes or no): bed mobility, transfers, and ambulation. From the nursing data, all 2-hour patient position documentation was reviewed to determine, for each day, whether the patient was documented to have assumed specified positions or performed activities, or was restricted from activity. Nursing position data was recorded as yes for the following categories if they were documented at any point during each day: activity order is bedrest, activity contraindicated status post procedure,

activity contraindicated due to hemodynamic instability, bed in chair position, sitting edge of bed, out of bed, up to bedside commode, up to chair, ambulate with assist, ambulate independently, up ad lib.

PAC Complications

PAC complication data were extracted from physician notes (admission history and physical, daily progress notes, procedure notes, consults, alert notes, and discharge summary) and physical therapy and occupational therapy documentation. Complications were noted as “observed” for each occurrence of: bleeding from PAC site, PAC dislodgement or accidental removal, or PAC induced arrhythmia.

PAC Limitations on Mobility

The following limitations on mobility due to PAC were recorded when observed: presence of intra-aortic balloon pump (IABP) which when placed via femoral artery necessitates a bedrest activity order, need for nursing staff to adjust PAC during mobility, fluctuating PAC values requiring modification or termination of physical therapy or occupational therapy session, patient discomfort related to PAC requiring modification or termination of physical therapy or occupational therapy session, and lack of attending physician activity order for ambulation outside of room limiting physical therapy or occupational therapy session.

Results

Patient Characteristics

Data from 366 patients was included in this study. There were 225 males (61.5%) and 141 females (38.5%). The mean age of the patient population was 57.2 years ($SD=14.7$, min=18, max=87). Primary diagnoses are shown in Table 1. Ejection fraction is shown in Table 2. Patients had an indwelling PAC for an average of 5.7 days ($SD=5.9$, min=1, max=46) for a total of 2097 patient days included in this analysis. Of the 366 patients, 321 (87.7%) were alive at PAC removal.

Mobility Data: Physical Therapy

There were 85 patients or 23% of the total patient population who received physical therapy evaluation and treatment, ranging from 1 to 12 sessions each, for a total of 183 physical therapy sessions for patients with an indwelling PAC. The number of physical therapy sessions per patient is shown in Table 3. Out of 183 physical therapy sessions, 75 included rolling (40.9%), 115 contained supine to sit (62.8%), 153 involved sit to stand (83.6%), 79 included chair transfer (43.2%), 101 had ambulation (55.2%), and 1 session included stairs (0.5%).

Mobility Data: Occupational Therapy

There were 15 patients or 4% of the patient population who received occupational therapy evaluation and treatment, ranging from 1 to 3 sessions each, for a total of 17 occupational therapy sessions for patients with an indwelling PAC. All patients who received occupational therapy also received physical therapy. Fourteen patients had 1 occupational therapy session,

1 patient had 3 occupational therapy sessions, and 351 patients had no occupational therapy sessions. Out of 17 occupational therapy sessions, bed mobility was completed 7 times (41.2%), transfers were completed 7 times (41.2%), and ambulation was included 4 times (23.5%).

Mobility Data: Nursing

Daily position and activity data were included for 2097 days with a PAC in place for 366 patients. It should be noted that the 2-hour position reports documented the position or activity of the patient at the time of documentation, and did not report all activity that occurred within the 2-hour period. Frequency of occurrence of different positions and activities are presented in Table 4.

PAC Complications

Out of 2097 days with a PAC in place for 366 patients, physician notes reported 15 occurrences of PAC complications (Table 5), occurring in 15 different patients. PAC complications included: bleeding from PAC site (3 occurrences), PAC dislodgement or accidental removal (5 occurrences), or PAC induced arrhythmia (7 occurrences). No occurrences of PAC complications were noted to have occurred during any physical therapy or occupational therapy session. Furthermore, no PAC complications were associated with nursing reported mobility activities.

PAC Limitations on Mobility

Of the 366 patients, 65 (17.8%) had an IABP and a bedrest activity order in place for a portion of their CICU stay. Out of 183 physical therapy sessions, there were 15 occurrences of PAC catheter mobility limitations noted for 12 patients. All 15 occurrences were cases where there was no activity order from the attending physician to allow ambulation outside of the patient's room with an indwelling PAC. Out of 17 occupational therapy sessions, there were 0 occurrences of PAC catheter mobility limitations.

Discussion

Evidence-based literature on mobility guidelines for patients with indwelling PACs is lacking. This retrospective, descriptive study of 366 patients was completed to describe the amount and type of documented mobility activity for patients with an indwelling PAC and to document the frequency and type of PAC complications. The patients in this study had a total of 2097 days with an indwelling PAC. During this time, they performed bed mobility, transfers, ambulation and even climbed stairs per physical therapy, occupational therapy and nursing documentation. There were 15 reports of PAC complications (bleeding, dislodgement or arrhythmia), however there were no reports of PAC complications during or in relation to participation in mobility activities (Table 5).

During the study period, there were 15 documented occurrences for PAC limitations on mobility during a physical therapy session. During this time, PTs were consulted to evaluate and treat patients with PACs, but for ambulation outside of the patient's room a specific order from the attending physician was required and a registered nurse had to be present and

monitoring the PAC waveform on a portable telemetry monitor at all times. All 15 occurrences of PAC limitations on mobility were documented as “lack of attending physician order for ambulation outside of room.” Through continuing quality improvement meetings with the ICU staff, discussions were held to promote early mobility initiatives and this limitation was identified as a barrier to early mobility and mobility progression with physical therapy. As a result, the policy was changed so that no additional activity orders were needed in order for patients with indwelling PACs to ambulate outside their room.

Beyond the variability in mobilization practices for patients with an indwelling PAC identified in our facility, variable practice in the ICU is a common finding in the literature across facilities.^{18–21} Programs which standardize practice and increase early mobility in the ICU have been described in various facilities; including guidelines on safe early mobility.^{8,18,19} The findings of this study further support safe, early mobility in the ICU, specifically for patients with PACs.

Out of 366 patients, 85 patients received physical therapy evaluation and treatment and 15 patients received occupational therapy evaluation and treatment with indwelling PACs. The majority of the sample did not work with physical therapy or occupational therapy when a PAC was in place; their mobility activities took place while monitoring by the nursing staff. While the amount and type of activity was precisely described in physical therapy and occupational therapy notes, it is much more broadly described in nursing notes. The nursing documentation provided 2-hour position reports, which consist of a mandatory selection from a list of possible choices every 2 hours. They report the position or activity of the patient at the time of documentation, and do not report all activity that occurred within the preceding 2-hour period. As a result, the frequency, amount and type of mobility activities that the patients actually performed with an indwelling PAC remains unknown. Hundreds of repetitions of mobility activities performed under nursing supervision were extracted and there were no reports of PAC complications related to these mobility activities.

Limitations

This study is a retrospective quality improvement study completed at a single center. As the data was obtained retrospectively, there was limited availability of frequency information for nursing documentation of mobility activity. There is also limited generalizability to acute care settings of different sizes or with different patient diagnoses or acuity. This study does not address the efficacy of physical therapy or occupational therapy interventions, only reports what type of mobility occurred during the sessions. The precise timing of PAC complications is unknown; documentation usually described a PAC complication event that had occurred “overnight” or “last evening”. Finally, a limitation to this study and all other studies of this type is that we were unable to describe what type of mobility activity will dislodge a PAC, and are only able to document activities that occurred that were not attributed to causing adverse PAC events such as dislodgement.

Conclusion

In an academic medical center CICU over a 29-month period, 366 patients with indwelling PACs performed bed mobility, transfers, ambulation and even climbed stairs with no PAC complications occurring during or in relation to participation in these mobility activities. Although studies support physical therapy and early mobility as a safe and effective intervention in ICU patients,^{8,9} we are the first to observe that patients with an indwelling PAC can participate in mobility activities in the CICU with no identified PAC complications related to participation in mobility activities noted within the study period. Future research is necessary to prospectively measure the effects of physical therapy on patients with an indwelling PAC and determine best practices, including effects of physical therapy intervention on length of stay, discharge and financial outcomes.

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Table 1

Patient Primary Diagnosis

Diagnosis	Frequency	Percent
Ventricular assist device/transplant workup	67	18.3
Listed 1A or 1AE for transplant	21	5.7
Heart failure	103	28.1
Respiratory failure	33	9.0
Renal failure	6	1.6
Myocardial infarction	49	13.4
Sepsis/endocarditis	16	4.4
Cardiac arrest/arrhythmia/syncope	48	13.1
PAC guided diuresis	23	6.3
Total	366	100.0

Table 2

Ejection Fraction

	Frequency	Percent
Less than 10%	24	6.6
10–19%	176	48.1
20–29%	61	16.7
30–39 %	23	6.3
40–49%	15	4.1
Greater than or equal to 50%	44	12.0
Unknown	23	6.3
<hr/>		
Total	366	100.0

Table 3

Number of Physical Therapy Sessions Per Patient

Number of Sessions	Frequency	Percent
0	281	76.8
1	48	13.1
2	16	4.4
3	8	2.2
4	6	1.6
5	1	.3
6	1	.3
7	2	.5
8	1	.3
10	1	.3
12	1	.3
Total	366	100.0

Table 4

Nursing Documentation of a Specified Position or Activity Occurring, per Day

Position or Activity	Frequency
Activity order is bedrest	319
Activity contraindicated status post procedure	26
Activity contraindicated due to hemodynamic instability	7
Bed in chair position	38
Sitting edge of bed	521
Out of bed	907
Up to bedside commode	78
Up to chair	343
Ambulate with assist	184
Ambulate independently	100
Up ad lib	126

Table 5

Physician Documentation Explaining Pulmonary Artery Catheter (PAC) Complications.

<i>Bleeding from PAC site</i>
“Swan removed overnight as suture fell-out, mildly bleeding”*
“Prolonged bleeding from cordis”*
“Notable drop in platelets (179 → 73 → 47) with worsening hemostasis of left femoral Swan-Ganz site. Patient requiring occlusive pressure with alternating staff over left groin to maintain hemostasis.”
<i>PAC dislodgement or accidental removal</i>
“Patient pulled out Swan overnight”
“Patient accidentally disconnected swan tubing and lost about 10 cc of blood according to her nurse”
“The patient’s central line became slightly loose yesterday as the suture securing it fell off....”“Difficulty with swan overnight, appears to have dislodged”
“Swan removed yesterday as noted to be in right atrium”
<i>PAC induced arrhythmia</i>
“Upon return from fluoroscopic PA catheter placement... he was noted to have increased rate of atrial/sinus tachycardia”
“Increase in ectopy overnight. Chest x-ray revealed swan catheter in right ventricle – was then removed”
“At midnight had ventricular tachycardia likely due to swan in right ventricle”
“The patient’s swan was in the right ventricle. This caused a run of ventricular tachycardia”
“At approximately 12:36 AM, while undergoing pulmonary artery thermodilution via Swan-Ganz catheter, patient was noted to suddenly become tachycardic and hypotensive”
“In the cath lab, standard right intrajugular access was achieved with ease. Swan was inserted. When in the right ventricle, his heart rate was noted to be in the 40s and this was persistent”
“Swan placed and then had atrial versus sinus tachycardia which returned after adenosine. Swan pulled back and replaced”

* Note: “Swan” is short for Swan-Ganz catheter, another name for PAC. “Cordis” refers to a large bore central line through which the PAC is inserted.