# Use of Electronic Tablets for Patient Education on Flushing Peripherally Inserted Central Catheters

Patricia L. Petroulias, PhD, MS, RN

**ABSTRACT**

The purpose of this study was to examine the efficacy of using an electronic tablet to provide patient education for flushing peripherally inserted central catheters (PICCs) as a way to reduce the incidence of occlusion. Eleven patients, newly diagnosed with cancer, participated in a pilot study that used a video on PICC flushing and remote coaching using FaceTime (Apple, Cupertino, CA) to teach patients how to maintain their PICCs in their homes. At the end of the 6-week intervention, no adverse outcomes (occlusions or infections) were noted among the patients who participated in the study.

**Key words:** electronic tablet, flushing, occlusion, patient education, peripherally inserted central catheter, PICCs

Health care providers use central vascular access devices (CVADs), such as peripherally inserted central catheters (PICCs), for infusion therapy to access a patient's venous circulation safely.[1] Such access allows providers to administer or deliver medications, especially vesicants and irritants, as well as larger volumes of fluid, into major veins with minimal risk of pain or damage to the vessel wall. PICCs are indicated in patients requiring at least 6 days and up to 1 year of infusion therapy.[2] Common indications for PICCs include a need for parenteral delivery of nutrition, antibiotics, and analgesics, as well as chemotherapy and repeated blood transfusions.[3] The Joint Commission has estimated that 3 million PICCs were placed in the United States in 2013.[4]

Potential complications have been associated with the use of PICCs. They include CVAD-associated infections, occlusion of the PICC, deep vein thrombosis of the upper extremity, catheter pinch-off syndrome, catheter dislodgment, catheter migration, superior vena cava syndrome, air embolism, or damage to the PICC itself.[5] This study focused on complications that are mutable with flushing: occlusion and infection.

The length of time a PICC remains functional is dependent on the care provided to prevent complications, such as occlusion or infections. PICCs may become occluded for several reasons, with thrombus the most common cause of occlusion. Virchow's triad is an explanation for the pathophysiological formation of vascular thrombus, involving the presence of 3 factors: (1) vessel wall damage or injury related to mechanical or irritant trauma, (2) blood flow obstruction, and (3) hypercoagulability of the blood.[6] Occlusion within the catheter lumen also can result from a reflux of blood into the catheter tip. Other causes of occlusion are associated with drug precipitate, lipid deposits, catheter pinch-off syndrome, or malposition of the catheter tip.[5] Reported PICC occlusion rates vary from 14% to 36%.[7,8] Such occlusions result in treatment delays, surgical replacement, patient discomfort, and increased patient care costs.[5]

Management of PICCs, as well as patient and caregiver education regarding these devices, is within the scope of nursing practice and is included in the Infusion Nurses Society's (INS') *Infusion Therapy Standards of Practice*[6] (the *Standards*) and standards of practice of the Oncology Nursing Society.[9] PICC occlusion can be attributed to poor maintenance techniques—specifically, failure to flush catheters properly or to use the locking solution recommended for a specific device.[5,10] Pulsatile catheter flushes with 0.9% sodium chloride routinely and after catheter use can assist in preventing occlusion.[11] The use of the pulsatile flushing technique with a 10-mL syringe is recommended to create

**Author Affiliations:** *Residential Home Care and Hospice, Troy, Michigan; and Oakland University, Rochester, Michigan.*

**Patricia L. Petroulias, PhD, MS, RN,** *received her PhD from Wayne State University in the College of Nursing. She has more than 35 years of experience as a nurse and has worked as a nurse educator and an oncology nurse. Currently, she is a director of education at Residential Home Care and Hospice in Troy, Michigan, and an assistant professor at Oakland University in Rochester, Michigan.*

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**Corresponding Author:** *Patricia L. Petroulias, PhD, MS, RN, 32442 Ridgefield Ave, Warren, MI 48088 (patjorgen@sbcglobal.net).*

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turbulence inside the tubing to clear it and decrease bacterial colonization.[6(pS78),10] Both the frequency and technique of flushing are important.

## PATIENT AND CAREGIVER EDUCATION

The insertion of a PICC can have a significant impact on patients' lives, especially when it is inserted into the dominant arm.[12] Effective patient and caregiver education is fundamental to providing infusion therapy safely and decreasing the risk of PICC-related complications.[5] The patient and caregiver need to be able to perform the tasks of PICC maintenance and know when to contact a health care provider if complications arise.

A major goal of nursing care is to promote positive patient outcomes by delivering infusion therapy free of complications.[6(pS31)] In most settings, nurses are responsible for providing patient and caregiver education related to maintenance of PICCs.[6(pS25)] Patients and caregivers need to learn and demonstrate appropriate techniques to prevent catheter occlusion to ensure safe and effective self-management. INS' *Standards* for patient and caregiver education includes device description, reason for placement, aseptic technique, basic device flushing, dressing and injection cap change, level of discomfort the patient may experience, site assessment for adverse outcome symptoms, potential complications, and prevention and management of complications.[6]

Because of the volume and complexity of the information, patients have described the education as unhelpful, excessive, and frightening.[1] Patients feel overwhelmed, and therefore, their retention of this critical information is limited.[1] Furthermore, care of PICCs in health care settings can be inconsistent when caregivers have different techniques for catheter flushing and care. How well patients and caregivers can maintain a patent PICC depends on their ability to learn new self-care behaviors and to integrate them into their health care practices. New self-care skills can be greatly impeded by a patient's state of being overwhelmed.

## PATIENT INFORMATION ABOUT SELF-CARE

Health care information often is acquired under substantial time pressures.[13] Clinical research has demonstrated that during and following periods of medical treatment, people experience substantial and persistent losses in their ability to focus and concentrate. Attentional ability cannot support information demands associated with many patient education approaches. The results of attentional loss are increased interferences that are expressed as an inability to concentrate on new information provided during patient education.[14] The capacity to direct attention is experienced as a loss of focus and concentration, as well as an increase in distractibility.

Northouse studied women who recently had been diagnosed with breast cancer.[15] The women were confronted with multiple informational, affective, and behavioral demands requiring considerable use of the capacity to direct attention during pretreatment and early postsurgical periods.[15] Examples of these demands included understanding the diagnosis and making treatment decisions under time pressure and high emotion, confronting existential concerns and family distress, adjusting to the loss of a breast, and modifying life activities to enable treatment. This loss of attentional capacity can have detrimental effects on recovery, impede learning new self-care activities, and result in being unable to cope with life-threatening illness.[14]

## ELECTRONIC TABLETS FOR PATIENT EDUCATION

With the proliferation of electronic tablets, smartphones, and other devices that can be used as teaching tools, patients can learn self-care techniques using electronic devices. Combining technology and educational theory can provide unique experiences for patients who are learning self-care techniques to manage their PICCs. The health care environment, in which learning is expected to occur, contains multiple distractions in the form of noise, traffic, and multiple caregivers in impersonal surroundings.[13] Such conditions are difficult to ignore and can decrease attention, requiring considerable mental effort simply to make sense of the environment and to overcome distractions before learning can occur. By shifting the learning environment to the patients' homes or environments of choice, the intervention can take place in a patient-controlled environment.

Using an electronic tablet to detail the steps required for flushing their PICCs could help patients master the process better than receiving the standard method of patient education. The standard method of education consists of an infusion nurse demonstrating how to flush the PICC and providing the patient with a printed handout describing the steps. Therefore, the intervention for this project was an initial face-to-face session for the patient with an infusion nurse, as well as coaching via FaceTime (Apple, Cupertino, CA) by means of an electronic tablet and access to a video that outlined the 10 steps of flushing (Appendix A).

## STATEMENT OF PROBLEM

PICC occlusion continues to occur frequently, despite the fact that this adverse patient outcome is considered preventable with adequate flushing of the device. As patients become more responsible for their self-care, educational interventions are needed to promote appropriate methods for maintaining PICCs. But current standard educational strategies continue to result in unacceptably high occlusion

rates for PICCs. For that reason, this study proposed a new strategy for patient and caregiver education: a comprehensive educational intervention, PICC self-care educational intervention (SCEI), using electronic tablets to reduce the incidence of PICC occlusion in adult outpatients who may be overwhelmed with self-care demands. The use of technology provides opportunities for repetition and self-paced learning that could help patients improve their ability to perform the self-care practices needed to care for their PICCs.

## STATEMENT OF PURPOSE

This pilot study had 2 purposes: in a sample of community-dwelling adults, (1) to test the feasibility of using electronic tablets to supplement patient and caregiver education about PICCs, and (2) to compare the percentage of PICC complications in the intervention group with national percentage rates for patients and caregivers who were educated using the standard method of education.

## METHODS

### Design

The pilot study employed a quasi-experimental research design to examine the incidence of occlusion and infection in a sample of patients with cancer who participated in a patient education program for flushing PICCs. The variables used to address the purpose of the study included the number of PICC occlusions and infections experienced by the participants. Research question 1 reported the frequency with which occlusion and infection incidences were reported. The second research question was tested using an analysis of frequency that compared the occlusion and infection rate of the present study with the national rates reported in the literature. All decisions on the statistical significance of the findings were made using a criterion alpha of .05. The research proposal was approved by the Institutional Review Board (IRB #68114M1F) at Wayne State University before beginning the research study.

### Sample

A sample of 11 oncology outpatients who had PICCs and were receiving treatment for cancer in outpatient infusion clinics, and/or their caregivers, participated in the study. Inclusion criteria included being 18 years of age or older, not pregnant, and diagnosed with cancer. Participants had to understand and communicate in English and be cognitively alert. All participants were familiar with electronic devices (eg, laptop computers, smartphones, electronic tablets) and were able to use the Internet to navigate the FaceTime application.

Participants were between 38 and 88 years of age, with a mean age of 66.64 (SD = 13.37) years. Four participants (36.4%) were male; 7 (63.6%) were female. Four (36.4%) participants reported their ethnicity as Caucasian, and 7 (63.6%) reported it as African American. Six (54.5%) participants were single, 4 (36.4%) were married, and 1 (9.1%) was widowed. Three (27.3%) participants had some high school education; an equal number indicated they were high school graduates. One (9.1%) participant had completed some college, and 2 (18.2%) reported they had obtained a bachelor of science degree. Two (18.2%) participants had attended a vocational or trade school (Table 1).

### Outcome Measures

#### *PICC patency*

Possible outcomes related to complications of occlusion include complete occlusion, partial occlusion, infection, or patency. According to the *Standards*, patency is defined as the ability to flush a catheter without resistance and the ability to yield a blood return.[6(pS104)] The presence of complete or partial occlusion was scored a 1; absence was scored a 0. The *Standards* also indicates that infection may include, but is not limited to, erythema, edema, pain, drainage, fluid accumulation at insertion site, and body temperature elevation.[6(pS106)] The presence of any sign of infection was scored a 1, and the absence was scored a 0.

**TABLE 1**

**Demographic Characteristics of the Sample (N = 11)**

| Variable | Mean | Standard Deviation |
|---|---|---|
| Age (range = 38-88 years) | 66.6 | 13.4 |
| Variables | Frequency | Percent[a] |
| Gender | | |
| Male | 4 | 36.4 |
| Female | 7 | 63.6 |
| Ethnicity | | |
| African American | 7 | 63.6 |
| Caucasian | 4 | 36.4 |
| Marital status | | |
| Single | 6 | 54.5 |
| Married | 4 | 36.4 |
| Widowed | 1 | 9.1 |
| Educational level | | |
| Some high school | 3 | 27.3 |
| High school graduate | 3 | 27.3 |
| Some college | 1 | 9.1 |
| Vocational or trade school | 2 | 18.2 |
| Bachelor of science | 2 | 18.2 |

[a]Percentages may not add to 100.0% due to rounding.

  

### *Successful demonstration of flushing by the patient or caregiver to researcher*

Patients or caregivers were asked to demonstrate their ability to complete the 10 steps of flushing while being observed by the researcher. The documentation included a checklist the researcher used to indicate whether the patient or caregiver was able to flush the PICC successfully. The score was a dichotomous variable, with 1 indicating success and 0 failure.

## Extraneous Variables

Extraneous variables could affect the outcomes of this study. These variables usually are uncontrolled and cannot be measured directly. Examples of extraneous variables with the potential to affect the study's outcomes include secondary infections unrelated to the PICC, a change in catheter design, the implementation of new health care policies, new medications or treatment procedures for patients with cancer, and a cure for cancer. Anecdotal notes were made if any extraneous variables occurred and affected treatment outcomes.

## Intervention

The researcher developed a training video for the care of PICCs, including flushing, following the *Standards*.[6] It was uploaded to YouTube (YouTube, San Bruno, CA) by the researcher. The researcher contacted participants after their PICCs were inserted. The principal investigator met with 4 participants in their homes and saw the remaining participants in outpatient infusion centers, where they were being treated. After consenting to take part in the study, each participant was given an iPad (Apple, Cupertino, CA) to use for 2 weeks. They received instructions about how to use the iPad and watched the video for PICC care and flushing. The researcher and participants connected by FaceTiming on their iPads. Participants performed their first independent flushing procedure while on FaceTime with the researcher. If a participant had a caregiver, the caregiver also was asked to participate in the flushing procedure. Participants returned to the infusion center at least once a week, where the infusion nurse examined the PICC for signs of occlusion and infection. The status of the PICC was documented by the infusion nurse at each visit for 6 weeks. While the number of visits may have varied among participants relative to their treatment regimen, data were collected once a week by the infusion nurse. At the end of the 6-week period, the intervention was considered completed.

## Data Analysis

Data were analyzed using IBM SPSS version 23 (IBM, Armonk, NY). The analyses used a combination of frequency distributions and measures of central tendency and dispersion to provide a profile of the participants. The continuous variables were summarized using descriptive statistics to present baseline information. The first research question was addressed using frequency distributions to determine the frequency of occlusions and infections that occurred during the 6 weeks following insertion of the PICCs. The second research question used an analysis of frequency to compare the occlusion and infection rates with the national average. An alpha level of .05 was used to determine the statistical significance of the findings.

# RESULTS

## Description of the Sample

Participants were asked about personal resources. The majority (n = 8; 72.7%) indicated they had a caregiver; 3 (27.3%) reported they did not have a caregiver. When asked if they used an electronic device (laptop computer, cell phone, or tablet), 9 (81.8%) responded yes and 2 (18.2%) indicated no. All participants had health insurance, and 10 (90.9%) were receiving home care services.

The patients were asked to indicate the type of cancer they had been diagnosed with. Their responses indicated that 3 (27.3%) had leukemia, 2 (18.2%) had ovarian cancer, 2 (18.2%) had pancreatic cancer, 1 had breast cancer (9.1%), 1 had bone cancer (9.1%), 1 had stomach cancer (9.1%), and 1 had lung cancer (9.1%) (Table 2).

## Research Questions

Two specific aims and associated research questions were developed for the study. The results of the statistical analyses used to address the research questions are presented in this section. All decisions on the statistical significance of the inferential statistical analyses were made using a criterion alpha level of .05.

### *Research Question 1: What is the number of PICC occlusions in adult outpatient participants who complete an SCEI for PICC care using an electronic tablet?*

PICC occlusion data were obtained from documentation in the medical records each week. Over the course of 6 weeks, 1 (9.1%) patient developed a thrombophlebitis in his upper arm that required removal of the PICC. This was the only adverse event recorded for the 10 participants who completed all components of the study.

**TABLE 2**

**Types of Cancer (N = 11)**

| Type of Cancer | n | %[a] |
|---|---|---|
| Leukemia | 3 | 27.3 |
| Ovarian | 2 | 18.2 |
| Pancreatic | 2 | 18.2 |
| Breast | 1 | 9.1 |
| Bone | 1 | 9.1 |
| Stomach | 1 | 9.1 |
| Lung | 1 | 9.1 |

[a]Percentages may not add to 100.0% due to rounding.

***Research Question 2:*** *Is there a difference in the percentage rate of occlusion in patients who have completed an SCEI for PICC care and national percentage rates of the same adverse outcomes in patients and caregivers who were educated by standard methods of education?*

The patients in the present study did not experience any occlusions during the 6 weeks of the intervention. The national reported rates of PICC occlusion varied from 14% to 36%.[7,8,16,17] Using analysis of frequency, the findings indicated that the present study had a significantly lower percentage of occlusion than was noted in national results ($P < .0001$).

### Anecdotal Findings

The experience of data collection yielded more information about the process of educating patients regarding flushing their PICCs. In one instance, a home care infusion nurse requested a demonstration of flushing because she was unsure about whether she was following protocol. She was using an alcohol pad to wipe the tip of the flushing syringe and had been teaching patients this process. Another infusion nurse reported that she did not teach the "push/pause" technique for flushing because she found this step confusing for patients and families. When discussing the current research and the *Standards* for flushing, she stated that she was aware of the information and that her practice was based on personal experience.

Patients were satisfied with the use of a tablet for providing education on flushing PICCs. At the 6-week follow-up appointment, 1 subject had purchased a tablet, informing his nurse that he used the tablet to watch movies during chemotherapy visits. Another subject asked how to purchase a tablet. He said his grandchildren used tablets and he had never considered using one, until he was able to use the tablet for the intervention study.

## DISCUSSION

The purpose of this study was to test the feasibility of using an electronic tablet to supplement patient and caregiver education about PICC maintenance and to compare the percentage of PICC complications in the intervention group with national percentage rates for patients and caregivers who were educated by standard methods. PICC occlusion data were obtained each week from the patients' medical records.

### Evaluation of Intervention

The pilot study of oncology patients with newly inserted PICCs demonstrated the positive effects of the use of technology to provide remote patient education and coaching in decreasing adverse patient outcomes of PICC occlusion. Adverse patient outcomes, such as occlusion, are considered preventable with adequate flushing. As patients become responsible for their self-care, educational interventions are needed to promote appropriate methods for maintaining PICCs. The standard method of PICC patient education has the infusion nurse demonstrating how to flush the PICC and providing the patient with a handout describing the steps. A new strategy for patient and caregiver education was developed for this study. The strategy used an SCEI that used electronic tablets to reduce the incidence of PICC occlusion in the adult outpatient population. The use of electronic tablets allowed repetition and self-paced learning to help patients improve their ability to perform the self-care practices needed to care for their PICCs. Previous research has demonstrated that electronic platforms for patient education improved interactive capabilities and supported communication needs beyond the inpatient setting.[18] Studies have used e-learning with mobile technology, both with electronic tablets and smartphones, with applications to improve educational outcomes in patients with chronic illnesses, including cancer, asthma, and diabetes.[19-21] Several researchers found increased patient engagement, decreased postdischarge complications, and improved communication between nurses and their patients.[19,22,23]

The outcomes of occlusion and infection were used to measure the effectiveness of the patient education intervention. All participants were successful in completing the PICC flush behaviors, as witnessed remotely by the researcher via an electronic tablet. Either the patient or the caregiver was able to successfully demonstrate the 10 steps of flushing. During the 6-week study, no occlusions were identified, with all PICCs assessed to be patent. Nationally reported PICC occlusion rates varied from 14% to 36%.[7,8,16,17]

### Study Limitations

The limitations of this study affected the generalizability of the findings to all patients with cancer. First, the sample size was small and sample selection was not random. Second, variations in the education of patients regarding PICC flushing practices and patient education were observed in this small study. The length of the intervention was brief (6 weeks). Some occlusion may have occurred after this time. Further research is needed to extend the length of time of the intervention.

## CONCLUSIONS

As a pilot study, the findings have importance regarding the future of educational interventions for patients with cancer. The results need to be replicated using a larger sample and with patients diagnosed with chronic illnesses that require self-care to determine whether the use of continuous education using electronic media is an appropriate patient education tool.

This study sought to determine whether an innovative educational intervention could provide a way to help patients with cancer with PICCs manage their self-care more effectively. Using an electronic tablet to provide step-by-step

instructions on PICC flushing had not been the subject of previous research in patients with cancer. Having a virtual face-to-face interaction in a home setting with an infusion nurse soon after the insertion of the PICC provided reinforcement of the education the patient had received about PICC management. The findings of the study regarding the lack of occlusion among the study participants provided support that such educational intervention merits further study.

## Implications and Recommendations

### *Nursing practice*

Nurses are responsible for patient education for maintenance of PICCs. As was noted in the anecdotal findings, the educational methods used by the nurses varied both in their own practice and with regard to the methods of other nurses, and were not grounded in evidence-based practice. To ensure consistency among infusion nurses, continuing education regarding the steps for flushing PICCs, based on current standards of practice, needs to be completed both by prelicensure nursing students and nurses practicing in the community.

A flushing video and an application for smartphones and tablets could be developed and distributed to schools and colleges of nursing, as well as organizations that employ infusion nurses. Before teaching patients and families self-care for PICCs, nurses could review current practice recommendations based on the *Standards*.[6]

Novel approaches to patient education need to be developed and tested. Developing applications for electronic tables and smartphones to support patient education can help overcome some of the visual and literacy problems associated with understanding printed materials. The use of electronic tablets to provide this type of education, while patients and caregivers are in the home environment, can provide opportunities for coaching, reviewing, and reinforcing self-care treatments that can improve health outcomes.

### *Nursing research*

This study should be replicated with a larger sample to determine whether the use of electronic tablets for patient education regarding flushing PICCs is a viable way to reduce the incidence of occlusions. Further testing of the use of electronic tablets to provide remote patient education and coaching could strengthen the evidence for integration of technology into programs designed to assist patients and caregivers in achieving self-care.

Additional research is needed on developing electronic tablet applications for self-care management of chronic illnesses, such as diabetes, heart failure, hypertension, and chronic obstructive pulmonary disease. An experimental study comparing 2 groups of patients—those who have access to the applications and those who receive standard patient education—could provide support for the use of electronic media for patient education.

## REFERENCES


1. Molloy D, Smith LN, Aitchison T. Cytotoxic chemotherapy for incurable colorectal cancer: living with a PICC-line. *J Clin Nurs*. 2008;17(18):2398-2407.
2. O'Grady NP, Alexander M, Burns LA, et al. Guidelines for the prevention of intravascular catheter-related infections. *Am J Infect Control*. 2011;39(4 suppl 1):S1-S34.
3. Tariq M, Huang DT. PICCing the best access for your patient. *Crit Care*. 2006;10(5):315.
4. The Joint Commission. Preventing Central Line–Associated Bloodstream Infections. A Global Challenge, A Global Perspective. Oak Brook, IL: Joint Commission Resources; 2012. https://www.jointcommission.org/assets/1/18/CLABSI_Monograph.pdf. Published 2012. Accessed May 16, 2017.
5. Gorski L, Perucca R, Hunter MR. Central venous access devices: care, maintenance, and potential complications. In: Alexander M, Corrigan A, Gorski L, Hankins J, Perucca R, eds. *Infusion Nursing: An Evidence-based Approach*. 3rd ed. St. Louis, MO: Saunders Elsevier; 2010:495-515.
6. Gorski L, Hadaway L, Hagle ME, McGoldrick M, Orr M, Doellman D. Infusion therapy standards of practice. *J Infus Nurs*. 2016;39(suppl 1):S1-S159.
7. Barrier A, Williams DJ, Connelly M, Creech CB. Frequency of peripherally inserted central catheter complications in children. *Pediatr Infect Dis J*. 2012;31(5):519-521.
8. Dougherty L. Frequency, diagnosis, and management of occlusive and mechanical PICC complications. In: Sandrucci S, Mussa B, eds. *Peripherally Inserted Central Venous Catheters*. New York, NY: Springer Milan Heidelberg; 2014:85-94.
9. Oncology Nursing Society. 2013 ASCO/ONS chemotherapy administration safety standards. https://www.ons.org/practice-resources/standards-reports/chemotherapy. Accessed April 27, 2016.
10. Ferroni A, Gaudin F, Guiffant G, et al. Pulsative flushing as a strategy to prevent bacterial colonization of vascular access devices. *Med Devices (Auckl)*. 2014;7:379-383.
11. Camp-Sorrell M, Camp-Sorrell D, eds. *Access Device Guidelines: Recommendations for Nursing Practice and Education*. 3rd ed. Pittsburgh, PA: Oncology Nursing Society; 2010.
12. Sharp R, Grech C, Fielder A, Mikocka-Walus A, Cummings M, Esterman A. The patient experience of a peripherally inserted central catheter (PICC): a qualitative descriptive study. *Contemp Nurse*. 2014;48(1):26-35.
13. Hong J, Nguyen TV, Prose NS. Compassionate care: enhancing physician-patient communication and education in dermatology: part II: patient education. *J Am Acad Dermatol*. 2013;68(3):364.e1-e364.e10.
14. Cimprich B, Visovatti M, Ronis DL. The Attentional Function Index—a self-report cognitive measure. *Psychooncology*. 2011;20(2):194-202.
15. Northouse LL. The impact of breast cancer on patients and husbands. *Cancer Nurs*. 1989;12(5):278-284. http://journals.lww.com/cancernursingonline/toc/1989/10000. Accessed May 16, 2017.
16. Lyons MG, Phalen AG. A randomized controlled comparison of flushing protocols in home care patients with peripherally inserted central catheters. *J Infus Nurs*. 2014;37(4):270-281.
17. Morano SG, Latagliata R, Girmenia C, et al. Catheter-associated bloodstream infections and thrombotic risk in hematologic patients with peripherally inserted central catheters (PICC). *Support Care Cancer*. 2015;23(11):3289-3295.
18. Abernethy AP, Etheredge LM, Ganz PA, et al. Rapid-learning system for cancer care. *J Clin Oncol*. 2010;28(27):4268-4274.
19. Kaufman N. Using health information technology to prevent and treat diabetes. *Diabetes Technol Ther*. 2014;16(suppl 1):S56-S67.


  

20. Sawyer T, Nelson MJ, McKee V, et al. Implementing electronic tablet-based education of acute care patients. *Crit Care Nurse*. 2016;36(1):60-70.
21. Nogueira PC, de Carvalho Nagliate P, de Godoy S, Rangel EM, Trevizan MA, Mendes IA. Technology use for health education to caregivers: an integrative review of nursing literature. *Appl Nurs Res*. 2013;26(3):101-104.
22. Granger BB, Bosworth H. Medication adherence: emerging use of technology. *Curr Opin Cardiol*. 2011;26(4):279-287.
23. Sherrard H, Struthers C, Kearns SA, Wells G, Chen L, Mesana T. Using technology to create a medication safety net for cardiac surgery patients: a nurse-led randomized control trial. *Can J Cardiovasc Nurs*. 2009;19(3):9-15.

## APPENDIX A

# Flushing a PICC: The 10 Steps of Flushing

The learner will flush his/her own PICC.

1. Wash your hands. Hand washing is the number one way to prevent infection and is critical in preventing this complication. A 2-minute hand washing with soap and water will be demonstrated.
2. Assemble all equipment: gloves, 1 10-mL sodium chloride flush syringe, 2 alcohol pads, mask. Each equipment piece will be held up by the instructor to demonstrate what it is.
3. Open sterile field and syringe packaging. Place syringes on sterile field. Open 2 alcohol pads and place on sterile field. Sterile is when there are no germs present. Because germs are present on us even after we wash our hands, we cannot touch a sterile field. Also, we cannot cough, sneeze, or pass over a sterile field with our hands or other objects.
4. Don sterile gloves and a mask. The process of putting on a mask and then sterile gloves without touching the outside of them will be demonstrated.
5. Scrub the hub of the catheter end cap for 15 seconds with alcohol pads. Vigorously rub end cap. The need to scrub the hub of the end cap will be emphasized as a way to prevent infectious bacteria from entering the PICC.
6. Attach 10-mL syringe with 0.9% sodium chloride to end of PICC lumen. The tip of the syringe will be placed in the hub of the end cap. The syringe will be held up to demonstrate that there are no air bubbles in the syringe.
7. Unclamp the lumen. The catheter has a roll clamp closing off fluid from entering and exiting the catheter when not in use. The roller clamp opening will be demonstrated.
8. Flush the catheter by intermittently pushing and pausing the plunger of the syringe; stop/start technique to flush.
9. Do not push plunger to the base of the syringe. This will be demonstrated by the instructor.
10. Disconnect the syringe. This will be demonstrated by the instructor. Clamp the catheter.