Marquette University

e-Publications@Marquette

College of Nursing Faculty Research and
Publications

Nursing, College of

6-2013

Quality Improvement Project: Analysis of Efficiency of Current Order Set for the Diagnostic Workup Used to Evaluate Neurogenic Stress Myocardium in Aneurysmal Subarachnoid Hemorrhage

Denise Miller Niklasch
Medical College of Wisconsin

Kathleen Bobay
Marquette University, kbobay@luc.edu

Follow this and additional works at: https://epublications.marquette.edu/nursing_fac

Part of the [Nursing Commons](#)

Recommended Citation

Niklasch, Denise Miller and Bobay, Kathleen, "Quality Improvement Project: Analysis of Efficiency of Current Order Set for the Diagnostic Workup Used to Evaluate Neurogenic Stress Myocardium in Aneurysmal Subarachnoid Hemorrhage" (2013). *College of Nursing Faculty Research and Publications*. 263.

https://epublications.marquette.edu/nursing_fac/263

Marquette University

e-Publications@Marquette

Nursing Faculty Research and Publications/College of Nursing

This paper is NOT THE PUBLISHED VERSION; but the author's final, peer-reviewed manuscript. The published version may be accessed by following the link in the citation below.

Journal of the American Association of Nurse Practitioners, Vol. 25, No. 6 (November 26, 2012): 314-319. [DOI](#). This article is © Wiley and permission has been granted for this version to appear in [e-Publications@Marquette](#). Wiley does not grant permission for this article to be further copied/distributed or hosted elsewhere without the express permission from Wiley.

Quality Improvement Project: Analysis of Efficiency of Current Order Set for The Diagnostic Workup Used to Evaluate Neurogenic Stress Myocardium in Aneurysmal Subarachnoid Hemorrhage

Denise Miller Niklasch

Department of Neurology, Medical College of Wisconsin, College of Nursing, Marquette University, Milwaukee, Wisconsin

Kathleen Bobay

College of Nursing, Marquette University, Milwaukee, Wisconsin

Abstract

Purpose

To evaluate patterns of utilization of the aneurysmal subarachnoid hemorrhage (aSAH) protocol order set for neurogenic stress myocardium (NSM).

Data sources

Retrospective chart review.

Conclusions

The results of this study demonstrate that protocol order sets can be prone to omissions, variations in practice, and delays.

Implications for practice

Education and implementation of an intervening compliance monitor are essential to improve utilization and correctness in use of the aSAH protocol order set for NSM. Advance practice nurses (APNs) or nursing staff could provide this service. This would improve teamwork, improve efficiency of care delivery and utilization of resources, promote leadership and improved outcomes, and promote relationship-based care.

Background

Aneurysmal subarachnoid hemorrhage (aSAH) is a deadly form of hemorrhagic stroke. There are 30,000 individuals suffering aSAH per year in the United States with adult women at greatest risk (Zacharia et al., **2010**) and is more common in the fifth to sixth decade of life (Zacharia et al., **2010**). Size of aneurysm, hypertension (HTN), and smoking are variables positively associated with risk of rupture (American Association of Neuroscience Nurses [AANN], **2007**; Greenberg, **2006**). Although computerized tomography (CT) of the brain is the test of choice to diagnosis aSAH (AANN, **2007**; Greenberg, **2006**) and CT angiogram now offers a noninvasive method, cerebral angiography remains the gold standard for identification of the location of the aneurysm (AANN, **2007**).

Rupture of an aneurysm forces blood into the subarachnoid space, which can extend into the intracerebral and intraventricular compartments (Greenberg, **2006**; Oman & Lavine, **2009**). Headache, specifically “the worst headache of my life,” is the most common presenting symptom (Greenberg, **2006**). Sentinel headache, a severe headache without neurological compromise, occurs in 30%–60% of patients with aSAH (Greenberg, **2006**). Other presenting symptoms include nuchal rigidity, seizures, syncope, nausea, vomiting, focal cranial nerve deficits, altered mental status, hemiplegia, coma, and death (Greenberg, **2006**; Oman & Lavine, **2009**; Zacharia et al., **2010**). The degree of clinical compromise is directly related to amount of blood with as many as 10%–15% dying prior to hospitalization (Brisman, Soliman, Kader, & Perez, **2009**; Greenberg, **2006**). Mortality ranges from 25% to 50% in hospitalized survivors with the rate of functional disability just under 50% (Brisman et al., **2009**; Greenberg, **2006**; Zacharia et al., **2010**). Mortality is directly related to the extent of aSAH, re-bleed, age of the individual, the presence of comorbidities, and medical complications (Greenberg, **2006**; Oman & Lavine, **2009**). Morbidity is directly linked to medical complications such as hydrocephalus, cerebral vasospasm (CVS), hyponatremia, cardiac abnormalities, seizure, and fever (AANN, **2007**).

Treatment considerations

Treatment goals include immediate control of systolic blood pressure (less than 140 mmHg), determining the location of the aneurysm and a timely securing of the aneurysm with surgical clipping or intra-arterial embolization to obliterate the aneurysm (AANN, **2007**). Once the aneurysm is obliterated, care focuses on close

neurological monitoring for CVS, defined as the narrowing of the cerebral arteries related to the transient thickening of the vessel walls (AANN, **2007**; Greenberg, **2006**). Onset of CVS is generally at 4 days post-bleed with duration of up to 20 days (Greenberg, **2006**). As many as 70% of individuals with aSAH will develop CVS with 30%–40% exhibiting clinical symptoms (AANN, **2007**; Greenberg, **2006**). Ischemic injury to the brain is the major complication of CVS (Greenberg, **2006**); therefore, in the presence of CVS, the focus of treatment is to maintain adequate cerebral perfusion.

Noninvasive treatment modalities for vasospasm include induced hypertension (with or without inotropic agents) and hypervolemia (AANN, **2007**; Brisman et al., **2009**; Greenberg, **2006**). In cases resistant to medical management, intra-arterial medications (verapamil and papaverine) or angioplasty can be used to treat CVS (Greenberg, **2006**).

One variable complicating management of CVS is cardiac dysfunction (Banki et al., **2005**, **2006**; Lee et al., **2006a**, **2006b**; Urbaniak, Merchant, Amin-Hanjani, & Roitberg, **2007**). Abnormalities include conduction abnormalities (T-wave inversions, prolonged QT waves, and arrhythmias), elevated troponin I (cTnI) levels, elevated brain natriuretic peptide (BNP), wall motion abnormalities, and reduction in left ventricular ejection identified by echocardiogram, or any combination of the above (Banki et al., **2005**, **2006**; Lee et al., **2006a**, **2006b**; Urbaniak et al., **2007**; Yarlagadda et al., **2006**).

Post-SAH cardiac dysfunction has been referred to in the literature as myocardial dysfunction, neurocardiogenic Injury, neurogenic myocardial stunning, apulla cardiomyopathy, left ventricular systolic dysfunction, or Takotsubo cardiomyopathy in the presence of aSAH and will be referred to as neurogenic stress myocardium (NSM) in this article (Banki et al., **2005**, **2006**; Lee et al., **2006a**). Norepinephrine (NE) toxicity has been implicated as the etiology of NSM. There is speculation that this toxicity occurs at the sympathetic terminals in the left ventricle causing left ventricular global or regional wall motion abnormalities and reduction in cardiac output in up to 20% of all cases (RWMA) and (Banki et al., **2005**, **2006**; Lee et al., **2006a**, **2006b**; Urbaniak et al., **2007**; Yarlagadda et al., **2006**).

Neurogenic stress myocardium

NSM is a temporary dysfunction that occurs during the first 72 h after aSAH with myocardial changes that do not correlate with a specific vascular territory (Banki et al., **2005**, **2006**; Kothavale et al., **2006**; Lee et al., **2006a**, **2006b**; Urbaniak et al., **2007**). Abnormal wall motion reduces cardiac output which, in turn, decreases cerebral blood flow and can cause an ischemic stroke (Banki et al., **2006**; Kothavale et al., **2006**; Lee et al., **2006a**, **2006b**; Urbaniak et al., **2007**). Although NSM is temporary it can last for months after the initial insult (Banki et al., **2006**; Kothavale et al., **2006**; Lee et al., **2006a**, **2006b**; Urbaniak et al., **2007**). NSM can result in clinical instability and may require vasopressors to maintain normal systolic blood pressure (greater than 100 mmHg).

In the presence of CVS after aSAH, hypervolemia may be required in order to optimize cerebral blood flow (Anderson, **2009**). However, increasing intravascular volume can stress a heart already compromised by NSM and can result in complete myocardial failure. It is essential, therefore, to evaluate for NSM prior to the initiation of hypervolemic therapy. Catecholamine panel (NE, epinephrine, dopamine, and total catecholamine), cardiac panel (cTnI, CK-MB, CPK, CK index), and BNP are laboratory studies used to predict NSM and an echocardiogram is useful in evaluating the extent of dysfunction. Because of the high risk of NSM in aSAH, BNP, cTnI and echocardiogram were added to the current intracerebral hemorrhage (ICH)/aSAH orders as a specific aSAH protocol in 2007 at our institution. Individual selection of the each diagnostic test is required to order the aSAH protocol set and there was no method incorporated to assure compliance.

Protocols or clinical pathways are used to define treatment options, providing a guide for anticipated therapies and giving direction to the plan of care. The aim of protocols and clinical pathways is to provide safe, efficient care, reduce length of stay (LOS), and reduce cost. But protocols that require selection increase the risk of omissions and variability of treatment. The overall focus of this study was to evaluate such variations in the utilization of order sets.

Literature search

A literature search was performed in OVID and PubMed using the terms “clinical guidelines,” “protocols,” and “clinical pathways” with cross references to APN and nurse. A total of 14 articles were identified from 2003 to 2010 of which nine were excluded. Six articles described the development of a protocol and three articles surveyed the use of protocols. The remaining five articles evaluated the utilization of an APN or registered nurse (RN)- managed protocol, although none directly evaluated APN protocol specific to NSM. The Standards for Quality Improvement Reporting Excellence (SQUIRE) were used to evaluate the research literature for analysis of the effectiveness of protocols and clinical pathways in improving efficiency of care, reducing LOS, and reducing cost.

Involvement of the nurse in the implementation of protocols developed to improve care was addressed by several authors. Burns et al. (2003) and Kanji et al. (2010) specifically stress the importance of the APN or RN as an individual designated to monitor the successful implementation of a protocol. Burns et al. (2003), in a combined retrospective and prospective review, demonstrated that a team approach to the utilization of a ventilator support protocol for patients on the ventilator for 3 days or more, with the APN as the manager of the protocol, demonstrated a reduction in overall ventilator days, intensive care unit (ICU) days, and hospital LOS.

The involvement of the APN or RN to monitor protocol compliance is further supported by Francavilla (2008), who in a retrospective chart review analyzed the use of a nurse-driven protocol at a nurse-managed anticoagulation clinic. Use of the nurse-driven protocol demonstrated an improvement in patient compliance to prescribed use of medications by 24%. In an observational study in which Broers et al. (2006) compared medical resident and APN use of inpatient and outpatient protocols after coronary artery surgery, the APN group demonstrated improved outpatient satisfaction without increase in complications. Further support for nurse-facilitated protocols comes from Davidson, Griffin, and Higgs (2007). Their retrospective chart audit of postoperative fluid management in patients with proximal femoral neck fractures showed a significant reduction in postoperative hypotensive episodes (8% compared to 33%)

In a retrospective and prospective cohort study of intravenous insulin therapy in the neurovascular and traumatic brain injury ICU population by Kanji et al. (2010), the protocol guided nursing staff in the treatment of hyperglycemia which resulted in improved median time to attain target blood sugar levels and a reduction in hypoglycemic episodes (Kanji et al., 2010). The protocol was physician initiated and it was managed by the bedside RN.

The literature also demonstrates that use of protocols leads to a reduction in LOS and cost. Broers et al. (2006) demonstrated a 32% decline in LOS after implementation of a protocol, and in Burns et al. (2003), use of a protocol led not only to a reduction in ventilator days, ICU, and hospital LOS but to an overall reduction in cost. Time to goal therapy is an additional important variable in reducing LOS and cost. Francavilla (2008) demonstrated a reduction in time to therapeutic goal using an anticoagulation protocol and an overall decrease in total office visits.

Current research in this area is limited, but the available literature supports the use of APN or nurse-managed protocols (Broers et al., 2006; Burns et al., 2003; Davidson et al., 2007; Francavilla, 2008; Kanji et al., 2010).

Protocols reduce LOS, inconsistencies in practice, complications, and costs while improving patient satisfaction and adherence to treatment regimens.

Theoretical framework

The relationship-based care model provided the theoretical framework supporting the use of a protocol order set (POS) in this study. Relationship-based care is a holistic approach to the coordination of the total care of the patient. According to principles of relationship-based care, the focus places the patient at the center of the treatment plan while engaging the nurse to promote teamwork, efficiency of care delivery, utilization of resources, leadership, and outcomes (Koloroutis, **2004**). The goal of a POS is to develop the plan of care in a sequence that provides the treatment team with guidelines for efficient care delivery and optimal utilization of resources, or incorporation of the relationship-based model. POSs enable the core team, including the nurse, to work autonomously and promote leadership while engaging in a collaborative relationship with the team. Coordination of these activities includes the nurse–patient relationship as well as that of the nurse with his/her colleagues. The sum of these components, teamwork, efficiency of care delivery, utilization of resources, leadership, and improved outcomes, is the basis of relationship-based care (Koloroutis, **2004**).

Methods

Design

The study was a retrospective medical record review to determine utilization of the aSAH protocol contained in the ICH/subarachnoid hemorrhage (SAH) order set. Charts of aSAH population were reviewed for the use of the ICH/SAH order set with use of the aSAH protocol order on day of admission, variation in use (including team vs. nonteam ordering), and delayed use, which is defined as order entry after the initial order set on the day of admission.

Sample

A convenience sample of consecutive patients diagnosed with aSAH (International Classification of Diseases [ICD-9] code 430) was obtained from the electronic patient database of a Midwestern tertiary-care hospital from January 1, 2008 to December 31, 2010. This time period was chosen because the aSAH order set was added to the ICH/SAH order set in 2007. Charts from 2007 and earlier were excluded because the implementation date of the 2007 revision could not be determined. The study population was defined as patients admitted with documented aSAH age 18–85. Documented aSAH was defined as SAH identified on CT scan or positive xanthochromia or blood identified in laboratory report of the cerebrospinal fluid (CSF) sample, as well as cerebral aneurysm identified on CT angiogram or cerebral angiogram.

The estimated population of aSAH was 80 cases per year or a total of 240 patients for a 3 year time period. After consultation with a statistician, it was determined that 160 cases was a sufficient sample. Retrospective chart review was performed to confirm diagnosis (as described above) and to confirm age (18–85) for inclusion in the study.

Procedure

This study was deemed a quality improvement project and considered exempt by the institutional review board. Charts were then reviewed by a single reviewer. Any patient with traumatic SAH, SAH related to mycotic aneurysm, or SAH related to arteriovenous malformation rupture was excluded from the sample population. In addition, charts were excluded if the date on the order set were prior to the 2007 revision, age less than 18 or greater than 85.

Charts were reviewed for the use of the ICH/SAH order set, use of the aSAH POS on day of admission, or delayed use. Data were entered as the use or nonuse of order set, use or nonuse of the aSAH POS, identification of specific diagnostic of the aSAH ordered, and for delay in POS entry. When a delay in ordering of the aSAH order set was noted, the length of delay was calculated. Delayed use was calculated by the actual time difference between the date and time on the admission ICH/SAH order set and the date and time of the handwritten protocol order. In the presence of delayed order entry, identification of the time of day and day of admission was documented to determine if the incidence for nonuse of the aSAH protocol order related to after-hours or weekend coverage of the Neurological Intensive Care Unit (NICU) to determine if the failure to use the protocol was related to staffing. The NICU has a designated team that provides coverage Monday through Friday from 6:00 a.m. to 5:00 p.m. with overnight and weekend coverage from the pool of general neurology residents. The percentage of NICU team versus pool coverage was calculated to provide documentation of the impact of the nondesignated NICU team members on utilization of the aSAH protocol. No specific data were collected in relationship to the APN because there was not a designated role of the APN for compliance monitoring.

Data analysis

Data were analyzed with SPSS software, version 17.0 (SPSS Inc, Chicago, IL). Percentage of occurrence was calculated for frequency of use of the ICH/SAH order set, frequency of use of the aSAH protocol order, and frequency of delayed entry of the aSAH POS. The frequency of use provided documentation of actual use of the order set and the aSAH protocol for comparison to nonuse or delayed use of the protocol order. Mean and standard deviation (SD) was calculated to evaluate time of delay. The time calculation provided the amount of the time that it took for the team to realize that the order had been missed.

Results

A search of all admissions with a diagnosis of aSAH from January 1, 2008 to December 15, 2010 identified 247 admissions. A total of 101 charts were excluded from the study with 47.5% ($n = 48$) incorrectly coded, 44.5% ($n = 45$) utilized the old order forms, 5% ($n = 5$) utilized incorrect order sets, and 3% ($n = 3$) did not meet the age requirement. Common diagnosis coded as aSAH included SAH associated with intracerebral/intraventricular hemorrhage related to other pathology ($n = 21$), SAH on CT scan with negative angiogram ($n = 20$), elective coil embolization of unruptured aneurysm ($n = 4$), seizure ($n = 1$), ischemic stroke ($n = 1$), and SAH consistent with aneurysm but without CT angiogram or angiogram confirmation because of the patient's death ($n = 1$). Incorrect order sets utilized included use of the ischemic stroke order set ($n = 2$), postoperative craniotomy order set ($n = 2$), handwritten orders or failure to use an approved order set ($n = 1$).

A total of 59 of the charts met the inclusion criteria with 50.8% ($n = 30$) of the orders completed by the NICU team. Incomplete ordering of the protocol was identified 67.8% ($n = 40$) of the time with a 44.1% ($n = 36$) incidence of delay in ordering. The time of delay ranged from 45 to 6960 min (116 h). The mean time of delay was 1285 min (21 h 25 min) with a SD of 1516 min (25 h and 16 min).

Each diagnostic test in the protocol was listed as a separate order selection on the order set. The purpose was to require the provider to determine the need for a diagnostic, but this also created inconsistencies in the ordering of the protocol for aSAH. The echocardiogram (88.1%, $n = 52$) was the most frequent order selected from the aSAH protocol followed by the cardiac panel (81.4%, $n = 48$). The BNP (47.5%, $n = 28$) and the catecholamine panel (40.7%, $n = 24$) were the least frequently ordered tests in the protocol.

Discussion

While POS have potential to reduce errors, reduce cost, and enhance delivery of care, the results of this study demonstrate that protocols can be prone to omissions, variations in practice, and delays. Results in this study

demonstrated that utilization of the aSAH protocol was inconsistent even though 50.8% of the order sets were completed by the NICU team. The BNP (47.5%) and the catecholamine panel (40.7%) were the most frequently omitted diagnostics. In addition to omissions, delay in ordering the aSAH protocol was identified in 44.1% of charts with a wide range in time of delay (45–1285 min).

The presence of omissions and delays suggests the need for additional measures to increase compliance. Monitoring of compliance with active intervention and facilitation in the utilization and correct use of the aSAH POS could be provided by the APN or the nursing staff. In studies performed by Broers et al. (2006), Burns et al. (2003), and Kanji et al. (2010), the incorporation of an APN or RN to monitor compliance while actively intervening was key to the success of the protocols. Broers et al. (2006) specifically identified the utilization of an APN in this role as the critical variable. Currently there is a single APN working in the NICU on 4/40 schedule (four 10 h days per week), which will not eliminate the risk inconsistencies and of delay OPS entry. The utilization of the APN would substantiate the collaborative role of the APN within the medical team and ultimately improve teamwork, efficiency of care delivery, utilization of resources, leadership, and outcomes, and promote relationship-based care (Koloroutis, 2004).

Limitations

The sample size was significantly reduced secondary to errors in coding non-aSAH and SAH with a negative CT angiogram or cerebral angiogram (47.5%) as aSAH. The utilization of the combined ICH/aSAH order may have been a variable in the incorrect coding. The development of a specific order set for aSAH could potentially reduce the incorrect coding of SAH with ICH or AVM, but it would not eliminate the risk of a non-aSAH being incorrectly coded as aSAH or the incorrect coding of aSAH.

An additional variable in reduction of the sample size was related to the use of the old order set. After discussion with those responsible for ordering the sets, it was found that the delay in using the new order sets was because of the practice of not ordering new forms until the existing supply had been used up. Thus, the revised sets were not ordered until October 29, 2008. This delay was an unpredictable variable that significantly reduced the population studied.

Other variables that may have influenced the data include the day and time of admission, faculty input, lack of awareness of the incorporation of the protocol into the order sets, and critical status of the patient at the time of admission. At the time of the order set revision the residents were sent a house-wide e-mail updating them on a series of order set revisions, plus a review of the order sets was incorporated into the monthly orientation of rotating residents. The lack of formal education on the implementation of an aSAH protocol in the ICH/aSAH order set was a potential deterrent to compliance.

Implications

Utilization of protocols orders has been shown to improve the overall efficiency and safety in patient care (Broers et al., 2006; Kanji et al., 2010). The utilization of the aSAH protocol was inconsistent (67.8%) and this demonstrates the need to reevaluate the format of the current order set. Revisions have been initiated to separate the aSAH from the combined ICH/aSAH set.

In addition, omissions in ordering have created a need for a compliance monitor. The unit APN will begin the role of the compliance monitor to intervene and facilitate utilization of the aSAH protocol as well as to assure correctness.

The variability in ordering of the aSAH protocol suggests either a lack of understanding of the rationale for the protocol or an individual interpretation of the value of each diagnostic. Staff education on the use of the

protocol is essential to reduce omissions and nonadherence (Davidson et al., **2007**; Kanji et al., **2010**). Formal education of the residents and nursing staff will be implemented prior to the introduction of the revised order set to assist in reducing noncompliance. Education will be employed in the format of monthly in-servicing of neurology residents, mass e-mail alert, designated nursing in-service, and on an individual basis.

There remains the potential that the variation in ordering is related to individual bias regarding the value of the diagnostics. This has initiated a literature review of the diagnostic studies used to predict aSAH to determine the sensitivity and specificity of each diagnostic. The results will be incorporated into the new aSAH POS.

Conclusions

This study demonstrates that there are inconsistencies that occur with utilization of POSs. Education, implementation of a compliance monitor, and intervention has proven to be beneficial in improving protocol compliance (Broers et al., **2006**; Burns et al., **2003**; Kanji et al., **2010**). The ability to activate the POS when it is omitted is a vital component to this role. Intervening is proactive and aimed at improving overall utilization and correctness of use of the aSAH protocol.

Further research is needed to evaluate the revised aSAH order set to determine if separation of the ICH order set and designating a compliance monitor to intervene are effective in improving utilization and accuracy of the aSAH protocol and to determine the effect of such a protocol on nursing practice.

Acknowledgments

The author would like to thank Christine Shaw, PhD, RN, Marquette University, Maria Wellenstein, MSN, ACNP, RN, Medical College of Wisconsin, and Kary Wiesler, BSN, RN, for their contributions to the manuscript.

References

- AANN. (2007). Care of the patient with aneurysmal subarachnoid hemorrhage. *American Association of Neuroscience Nurses: AANN Clinical Practice Series*. 1– 26. Retrieved from <http://www.aann.org/pubs/cpg/sah090213.pdf>
- Anderson, T. (2009). Current and evolving management of subarachnoid hemorrhage. *Critical Care Nursing Clinics of North America*, **21**(4), 529– 539. doi:[10.1016/002Fj.ccell.2009.07.018](https://doi.org/10.1016/002Fj.ccell.2009.07.018)
- Banki, N., Kopelnik, A., Tung, P., Lawton, M. T., Gress, D., Drew, B., ... Zaroff, J. (2006). Prospective analysis of prevalence, distribution, and rate of recovery of left ventricular systolic dysfunction in patients with subarachnoid hemorrhage. *Journal of Neurosurgery*, **105**(1), 15– 20. doi:[10.3171/jns.2006.105.1.15](https://doi.org/10.3171/jns.2006.105.1.15)
- Banki, N. M., Kopelnik, A., Dae, M. W., Miss, J., Tung, P., Lawton, M. T., ... Zaroff, J. G. (2005). Acute neurocardiogenic injury after subarachnoid hemorrhage. *Circulation*, **112**(21), 3314– 3319. doi:[10.1161/CIRCULATIONAHA.105.558239](https://doi.org/10.1161/CIRCULATIONAHA.105.558239)
- Brisman, J. L., Soliman, E., Kader, A., & Perez, N. (2009). Cerebral aneurysm. *eMedicine*. Retrieved from <http://emedicine.medscape.com/article/252142-overview>
- Broers, C., Hogeling-Koopman, J., Burgersdijk, C., Cornel, J. H., van der Pleg, J., & Umans, V. (2006). Safety and efficacy of a nurse-led clinic for post-operative coronary artery bypass grafting patients. *International Journal of Cardiology*, **106**, 111– 115. doi:[10.1016/002Fj.ijcard.2005.03.009](https://doi.org/10.1016/002Fj.ijcard.2005.03.009)
- Burns, S. M., Earven, S., Fisher, C., Lewis, R., Merrell, Schubart, J. R., ... Bleck, T. P. (2003). Implementation of an institutional program to improve clinical and financial outcomes of mechanically ventilated patients: One-year outcomes and lessons learned. *Critical Care Medicine*, **31**(12), 2752– 2763. doi:[10.1097/01.CCM.0000094217.07170.75](https://doi.org/10.1097/01.CCM.0000094217.07170.75)
- Davidson, J., Griffin, R., & Higgs, S. (2007). Introducing a clinical pathway in fluid management. *Journal of Perioperative Practice*, **17**(6), 248– 256.
- Francavilla, C. L. (2008). Registered nurse-managed anticoagulation clinic: Improving patient outcomes. *Nursing Economics*, **26**(2), 130– 132.

- Greenberg, M. S. (2006). Aneurysms. In M. S. Greenberg (Ed.), *Handbook of neurosurgery* (pp. 781– 834). New York, NY: Thieme Medical Publishing.
- Kanji, S., Jones, E., Goddard, R., Meggison, H. E., & Neilipovitz, D. (2010). Efficiency and safety of a standardized protocol for intravenous insulin therapy in ICU patients with neurovascular or head injury. *Neurocritical Care*, **12**(1), 43– 49. doi:[10.1007/s12028-009-9275-z](https://doi.org/10.1007/s12028-009-9275-z)
- Koloroutis, M., Manthey, M., Felgen, J., Kinnaird, L., Wright, D., & Dingman, S. (2004). *Relationship-based care: A model for transforming practice*. Minneapolis, MN: Creative Health Care Management, Inc.
- Kothavale, A., Banki, N. M., Kopelnik, A., Yarlagadda, S., Lawton, M. T., Ko, N., ... Zaroff, J. G. (2006). Predictors of left ventricular regional wall motion abnormalities after subarachnoid hemorrhage. *Neurocritical Care*, **4**(3), 199– 205. doi:[10.1385/Neurocrit.Care](https://doi.org/10.1385/Neurocrit.Care) 2006;04:199-205
- Lee, V. H., Connolly, H. M., Fulgham, J. R., Manno, E. M., Brown, R. D., Jr., & Wijdicks, E. F. (2006a). Tako-tsubo cardiomyopathy in aneurysmal subarachnoid hemorrhage: An underappreciated ventricular dysfunction. *Journal of Neurosurgery*, **105**(2), 264– 270. doi:[10.3171/jns.2006.105.2.264](https://doi.org/10.3171/jns.2006.105.2.264)
- Lee, V. H., Oh, J. K., Mulvagh, S. L., & Wijdicks, E. F. (2006b). Mechanisms in neurogenic stress cardiomyopathy after aneurysmal subarachnoid hemorrhage. *Neurocritical Care*, **5**(3), 243– 249. doi:[10.1385/Neurocrit.Care](https://doi.org/10.1385/Neurocrit.Care) 2006;05:243-249
- Oman, J. A., & Lavine, S. D. (2009). Subarachnoid hemorrhage. *eMedicine*. Retrieved from <http://emedicine.medscape.com/article/247090>
- Urbaniak, K., Merchant, A. I., Amin-Hanjani, S., & Roitberg, B. (2007). Cardiac complications after aneurysmal subarachnoid hemorrhage. *Surgical Neurology*, **67**(1), 21– 28. doi:[10.1016/j.surneu.2006.08.065](https://doi.org/10.1016/j.surneu.2006.08.065)
- Yarlagadda, S., Rajendran, P., Miss, J. C., Banki, N. M., Kopelnik, A., Wu, A. H., ... Zaroff, J. G. (2006). Cardiovascular predictors of in-patient mortality after subarachnoid hemorrhage. *Neurocritical Care*, **5**(2), 102– 107. doi:[10.1385/Neurocrit.Care](https://doi.org/10.1385/Neurocrit.Care) 2006;05:102–107
- Zacharia, B. E., Hickman, Z. L., Grobelny, B. T., DeRosa, P., Kotchetkov, I., Ducruet, A. F., & Connolly, E. S., Jr. (2010). Epidemiology of aneurysmal subarachnoid hemorrhage. *Neurosurgery Clinics of North America*, **21**(2), 221– 233. doi:[10.1016/j.nec.2009.10.002](https://doi.org/10.1016/j.nec.2009.10.002)