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# Decreased Odds for Vasospasm Treatment in Patients with Aneurysmal Subarachnoid Hemorrhage after Transitioning from Neurosurgery Led Care to a Neurology Led Multidisciplinary Approach

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## Abstract

**Introduction—**The limited research on the management of aneurysmal subarachnoid hemorrhages (aSAHs) has not assessed the efficacy of neurology-led care. Our objective was to describe aSAH patients' outcomes after transitioning from a neurosurgery-led intensive care unit (ICU) to a neurology-led multidisciplinary care neurocritical care unit (NCCU). The study hypothesis was that the neurology-led multidisciplinary care would improve patient outcomes.

**Methods—**This was a retrospective cohort study. We included patients (≥ 18) with aSAHs from 1/16 to 8/16 (pregroup) and from 3/17 to 11/17 (postgroup). The pregroup care was led by a neurosurgeon. The postgroup care included a neurologist, a pulmonary intensivist, a neurocritical care clinical nurse specialist, a neurosurgeon, and euvolemia protocol. The primary outcome was trips to interventional radiology (IR) for vasospasm treatment. Univariate analyses and multivariable ordinal logistic regression were used.

**Results—**There were 99 patients included: 50 in the pregroup and 49 in the postgroup. On average, postgroup patients were 7 years older than the pregroup ($p = 0.05$); no other demographic or clinical characteristics significantly differed. The odds were 62% lower that the postgroup had a higher number of trips to IR for vasospasm treatment, when compared to the pregroup, $p < 0.001$.

**Conclusions—**In aSAH patients, the neurology-led multidisciplinary care in the NCCU decreased the odds of repeated procedures for vasospasm treatment. Neurology-led multidisciplinary care could be more cost-effective than the neurosurgical-led care.

## INTRODUCTION

The limited research on aneurysmal subarachnoid hemorrhage (aSAH) management assessed the efficacy of neurointensivist-led multidisciplinary care on patient outcomes when compared to neurosurgical- or neurology and neurosurgical-led care [1–3]. In these studies, outcomes included length of stay (LOS), discharge disposition, mortality, ventriculoperitoneal (VP) shunt placement, ventilator-acquired pneumonia, and delayed cerebral ischemia (DCI). No studies compared the number of trips to interventional radiology (IR) for vasospasm treatment in aSAH patients by management type.

Up to 70% of aSAH patients develop vasospasm, defined as cerebral artery narrowing on angiography, typically between 4 and 14 days after an aneurysm ruptures [4–6]. In aSAH patients, DCI from vasospasm remains the greatest cause of death [7]. Endovascular rescue treatments for vasospasm, including balloon angioplasty and intraarterial vasodilators, decrease the risk for infarction, but recurrent vasospasm remains a complication [8,9]. Repeated vasospasm treatments have been used as an outcome to compare endovascular rescue treatments [8–10]. In a study examining 78 patients,

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Elliot *et al.* [10] found 42% of patients treated with an intraarterial vasodilator, and 1% of patients treated with balloon angioplasty required repeated treatment.

The study objective was to compare outcomes in those suffering an aSAH before and after transitioning from neurosurgery-led care in the intensive care unit (ICU), to neurology-led multidisciplinary care in the neurocritical care unit (NCCU). The study hypothesis was that neurology-led multidisciplinary care would improve patient outcomes.

## METHODS

This single-center retrospective cohort study was approved by the Swedish Medical Center Institutional Review Board with a waiver of patient consent. Inclusion criteria were: (1) ≥ 18 years old; (2) admitted to the ICU between January 1, 2016 and August 31, 2016 (pregroup) or admitted to the NCCU between March 1, 2017 and November 31, 2017 (postgroup); and (3) for aSAH treatment. Patients were identified by a positive angiography for nontraumatic aSAH. Data were collected from NeuroBase (St. Augustine, FL); missing and additional variables were abstracted by study personnel. Patients were excluded if the SAH was not caused by an aneurysm or transfer patients who received care other than at an outside facility's emergency department.

The pregroup care was neurosurgery-led in the ICU with 16 beds dedicated to neurologic patients. A neurointensivist was available upon consult from January 1, 2016 through March 31, 2016 for pregroup care. The postgroup care was a neurologist-led multidisciplinary approach including a pulmonary intensivist, neurocritical care clinical nurse specialist, and a neurosurgeon, in an 18-bed NCCU. Furthermore, a euvolemia protocol was implemented at the start of the postgroup timeframe.

All aSAH patients had permissive or pharmacologically augmented blood pressure and daily transcranial Doppler ultrasound to monitor flow velocities and identify vasospasm. Treatment decision was at the discretion of the primary treating physician and the interventional team. Common reasons for vasospasm treatment in the IR included highly elevated flow velocities or new signs of clinical deterioration. Vasospasm treatments included balloon angioplasty and intraarterial vasodilator infusions.

The primary outcome was the number of trips to IR for vasospasm treatment. Additional outcomes investigated included hospital LOS, ICU/NCCU LOS, in-patient ischemic stroke, mortality, discharge modified Rankin Scale (mRS), and hospital discharge disposition. Mortality included in-hospital mortality and hospital discharge to hospice. Ischemic stroke etiologies were categorized as vasospasm, procedural, vasospasm procedural, or other. Demographic and clinical characteristics collected were age, race, admission Hunt-Hess grade, admission mRS, admission Fisher's grade, pre-injury medications, and comorbidities.

Descriptive data were expressed as means and standard deviation, median and interquartile range, or proportions. Statistical differences were assessed using Fisher's exact test, Mann-Whitney U-test, Wilcoxon rank-sum test, or chi-squared when appropriate. Multivariable ordinal stepwise logistic regression and multivariable stepwise logistic regression were used to determine if outcomes were independently associated with a management approach. Data were analyzed using SAS 9.4 (Cary, NC) software, with an alpha value of 0.05.

## RESULTS

The final study population consisted of 99 patients: 50 pregroup and 49 postgroup patients. Most patients (65%) were female. Seventy-two percent of patients were assigned an admission Hunt-Hess grade I–III, and 27% were assigned a grade of IV and V. Demographic and clinical characteristic comparisons indicated the two groups were similar, except that on average, postgroup patients were seven (16) years older than pregroup patients, ($p = 0.05$).

Most methods for treating aneurysms were not significantly different. Thirty-two (64%) pregroup and 32 (65%) postgroup patients had endovascular coiling. Five (10%) pregroup and nine (18%) postgroup patients had endovascular coiling with stent placement. Surgical clipping was done in five (10%) pregroup and three (6%) postgroup patients. Seven (14%) pregroup and three (6%) postgroup patients had a VP shunt placed. A pipeline embolization device was placed in three (6%) pregroup and two (4%) postgroup patients. Three (6%) pregroup and three (6%) postgroup patients did not receive definitive aneurysm treatment. An EVD was placed in 21 (47%) pregroup and 24 (53%) postgroup patients. One (2%) pregroup and seven (14%) postgroup patients had a hemicraniectomy ($p = 0.03$).

All LOSs were similar between groups. The pregroup's median hospital LOS was 18 days (8–28) and the postgroup's was 18 days (10–26), $p = 0.27$. Pregroup patients had a median ICU LOS of 14 days (7–21); similarly, the postgroup's was 14 days (10–18), $p = 0.86$.

**Table 1. Outcomes unadjusted and adjusted odds ratios.**

| Outcome *N* (%) | Postgroup *N* = 49 | Pregroup *N* = 50 | *p* |
|---|---|---|---|
| Vasospasm Treatments | | | |
| 0 | 75.51% (37) | 74% (37) | |
| 1 | 6.12% (3) | 8% (4) | |
| 2 | 6.12% (3) | 4% (2) | |
| 3 | 8.16% (4) | 2% (1) | |
| 4 | 4.08% (2) | 2% (1) | |
| 5 | 0% (0) | 0% (0) | |
| 6 | 0% (0) | 2% (1) | |
| 7 | 0% (0) | 4% (2) | |
| 8 | 0% (0) | 4% (2) | 0.46 |
| OR (95% CI) | 0.38 (0.22, 0.66) | Ref. | **<0.001** |
| AOR[a] (95% CI) | 0.41 (0.23, 0.72) | Ref. | **0.002** |
| Vasospasm[b] | 13 (26.53%) | 14 (28%) | >0.99 |
| OR (95% CI) | 0.93 (0.34, 2.25) | Ref. | 0.87 |
| AOR[c] (95% CI) | 1.32 (0.50, 3.55) | Ref. | 0.57 |
| Ischemic stroke | 15 (30.61%) | 18 (36%) | 0.67 |
| OR (95% CI) | 0.78 (0.34, 1.81) | Ref. | 0.57 |
| AOR[a] (95% CI) | 0.96 (0.40, 2.31) | Ref. | 0.92 |
| Discharge mRS[d] ≤ 2 | 12 (24.49%) | 17 (34%) | 0.38 |
| OR (95% CI) | 0.62 (0.26, 1.51) | Ref. | 0.30 |
| AOR[a] (95% CI) | 0.79 (0.31, 2.00) | Ref. | 0.62 |
| Mortality[e] | 12 (28.57%) | 11 (22%) | 0.49 |
| OR (95% CI) | 1.42 (0.57, 3.53) | Ref. | 0.45 |
| AOR[f] (95% CI) | 1.25 (0.38, 4.05) | Ref. | 0.71 |

*a*: Adjusted for age;

*b*: patients who went to IR for vasospasm treatment or had an ischemic stroke caused by a vasospasm;

*c*: adjusted for age and sex;

*d*: mRS (favorable: 0–2, unfavorable: 3–6);

*e*: in-hospital mortality or discharge to hospice;

*f*: adjusted for Hunt and Hess (Favorable: 0–2 Unfavorable: 3–4);

IR: interventional radiology; OR: odds ratio; AOR: adjusted odds ratio; CI: confidence interval; Ref: reference.

Discharge disposition remained comparable across study arms. Two (5%) pregroup and five (14%) postgroup patients were discharged to a skilled nursing facility. Fifteen (38%) pregroup and fourteen (40%) postgroup patients were discharged to acute rehabilitation. Finally, 22 (56%) pregroup and 16 (46%) postgroup patients were discharged to home or home health.

Eighteen pregroup patients (36%) and 15 postgroup patients (31%) developed an ischemic stroke. Of the ischemic strokes, five (28%) pregroup and five (33%) postgroup were vasospasm-caused. One (6%) pregroup and one (7%) postgroup were vasospasm and procedurally-caused. Nine (50%) pregroup and four (27%) postgroup were procedurally caused. Three (17%) pregroup and five (33%) postgroup stroke etiologies were classified as "other." None of the differences seen were significant. However, there was a significant decrease in patients requiring repeated vasospasm treatment.

The odds were 62% lower that the postgroup had a higher number of trips to IR for vasospasm treatment, when compared to the pregroup, $p < 0.001$, seen in Table 1. After adjusting for age, the odds were 59% lower that the postgroup had a higher number of trips to IR for vasospasm treatment when compared to the pregroup, $p = 0.002$. All other outcomes were comparable to the prior neurosurgical-led care. There were 13 postgroup (27%) and 14 pregroup patients (28%) with an angiography-confirmed vasospasm. Twelve postgroup (29%) and 11 pregroup patients (22%) died in-hospital or were discharged to hospice. After adjustment for age, Hunt-Hess, or sex, there were no significant differences between groups for any other outcome.

## DISCUSSION

The American Heart Association/American Stroke Association (AHA/ASA) recommends aneurysm treatment determination to be made by a multidisciplinary team but does not make any recommendations for primary care service type [11]. This study suggests that neurology-led multidisciplinary care can significantly decrease the number of trips to IR for vasospasm treatment for aSAH patients while maintaining comparable results to neurosurgical-led care. This is consistent with previous research on aSAH management, which found multidisciplinary care positively impacted LOS, discharge disposition, VP shunt placement, and discharge mRS [1–3]. Multidisciplinary care is becoming more common for neurocritical care patients.

In addition to the management change, the postgroup treatment also included a euvolemia protocol, recommended by the AHA/ASA to prevent DCI [11]. Although the postgroup was treated with a euvolemia protocol, our study did not find a significant change in the number of in-patient ischemic strokes. However, there was a significant decrease in the number of trips to IR for vasospasm treatment. For many years, triple-H protocols (hemodilution, hypervolemia, and hypertension) have been used to treat vasospasms based on the theory that they will increase arterial blood pressure and cerebral brain flow through vasospastic arteries, but a 2010 literature review found there were sparse data to support this theory, and that hypervolemia can lead to volume overload [5,12]. Furthermore, the AHA/ASA recommends not to use hypervolemia for vasospasm prevention [12]. Another literature review conducted in 2014 recommended monitoring euvolemia instead of hypervolemia for vasospasm prevention [13]. The multidisciplinary approach facilitated the implementation of the euvolemia protocol by the neurocritical care clinical nurse specialist, which may have played a role in the decreased number of trips to IR for vasospasm treatment.

This study has its limitations. The sample size was relatively small, which limited the number of confounders

that could be controlled. Timing of IR treatments was not collected; therefore, the ability to understand how the number of trips to IR affects the risk of ischemic stroke was limited. Furthermore, this study was a single-center retrospective study and could not follow-up with neurologic outcomes after hospital discharge.

## CONCLUSIONS

In patients with aSAH, neurology-led multidisciplinary care in the NCCU significantly decreased the odds of repeated procedures for vasospasm treatment. Other outcomes were maintained comparable to the prior neurosurgical-led care in the ICU. This decrease in repeated IR procedures for vasospasm treatment undoubtedly reduced the financial burden of hospitalization and lowered the utilization of scarce hospital resources for aSAH patients treated in the neurology-led multidisciplinary care group.

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