THE EFFECT OF A CRITICAL PATHWAY ON PATIENTS’ OUTCOMES AFTER CAROTID ENDARTERECTOMY

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BACKGROUND In 1996, an integrated plan of care was implemented to improve quality of care for patients undergoing elective carotid endarterectomy. Goals were to reduce length of stay, costs, number of preoperative and intensive care unit admissions, and use of diagnostic procedures yet maintain good outcomes.

OBJECTIVES To determine whether use of the integrated plan of care met the goals.

METHODS Data on financial and process outcomes, use of angiographic diagnostic procedures, and demographics were retrieved from the hospital’s database for all patients who had elective carotid endarterectomy without cerebral infarction.

RESULTS A total of 783 patients met inclusion criteria: 129 before implementation of the plan of care, 66 during the 6-month transition, and 588 after implementation. Preoperative angiography was done in 32% of patients before implementation, 11% during the transition, and 4% after implementation. Percentages of patients admitted to the intensive care unit were 77% before implementation, 24% during transition, and 9% after implementation. Mean lengths of stay were 2.93 days before implementation, 2.12 days during transition, and 1.68 days after implementation. Costs per case were $7798 before implementation, $5750 during transition, and $5387 after implementation. Analysis of variance revealed significant differences between groups in total length of stay (P = .001), preoperative length of stay (P<.001), and costs (P<.001).

CONCLUSION Use of the integrated plan of care reduced length of stay, costs, admissions to intensive care units, and use of cerebral angiography. Use of the plan improved resource utilization while maintaining quality of care. (American Journal of Critical Care. 2002;11:250-260)
procedure in the United States. The procedure has become the standard therapy of choice for preventing debilitating strokes in patients with greater than 70% stenosis of the carotid artery, whether the patients have signs and symptoms of cerebral ischemia or not. The most significant risk factors associated with the procedure are stroke, acute myocardial infarction, and pulmonary complications. Improved technological capabilities and effective postoperative monitoring have reduced the risk of complications to acceptable levels compared with the risk of stroke due to significant stenotic lesions.

Review of the Literature

Several trends are apparent in the current management of patients undergoing elective carotid endarterectomy. A number of institutions are using clinical pathways or protocols to manage this population of patients. The purpose of most of the protocols is to reduce preoperative and postoperative lengths of hospital stay, decrease routine use of preoperative angiography, and use the intensive care unit (ICU) for selective admission of patients. Accessibility of specialized units for postoperative care of patients after carotid endarterectomy is an important factor that makes it possible to decrease the use of ICUs.

Outcome measures before and after implementation of a clinical pathway have been compared. Common outcome variables studied include total length of stay, preoperative length of stay, and postoperative length of stay. Other variables include hospital costs, morbidity and mortality rates, outcomes by type of anesthesia, and the use of preoperative angiography.

Inclusion and exclusion criteria differed among studies. Some studies included only patients undergoing elective carotid endarterectomy, whereas others included both elective and emergent cases. Information gained from these studies is that the length of hospital stay and costs can be reduced without increasing morbidity and mortality rates for these patients. The degree to which use of general versus regional anesthesia makes a difference in complication rates was addressed in several studies. Outcomes of studies in which similar clinical pathways were evaluated are summarized in Table 1.

Background for the Study

In the spring of 1996, a multidisciplinary collaborative practice team developed an integrated plan of care (IPOC) for patients undergoing carotid endarterectomy (Table 2). This initiative was based on evidence found in the research literature about the management of patients undergoing this procedure. The major emphasis behind this initiative to improve performance was to address practice issues across the continuum of hospital care and to streamline care with coordinated efforts while maintaining quality. Utilization of resources was addressed by use of specific protocols that reduced unnecessary use of oxygen and monitoring, routine preoperative use of cerebral angiography, and ICU stay. One goal was to reduce length of stay and costs by discharging patients who met set outcomes criteria on the day after surgery. In order to reduce ICU admissions, a step-down, monitored care unit was designed so that arterial monitoring could be used and the plan of care could be followed outside the traditional ICU. The clinical nurse specialist on the team facilitated development of the unit, education and guidance for the unit’s staff, and monitoring of outcomes. A 6-month transition phase was implemented with intensive monitoring and use of the new protocol for patients having carotid endarterectomy.

Evidence indicated that the protocol was successful in the first year of its introduction. During the first 6 months, adaptation to the protocol was variable; however, by the end of the first year, costs per case and length of stay had diminished. Since inception of the protocol, a specific vascular surgical unit with staff trained to manage patients who have carotid endarterectomy has been opened. Only minor revisions in the protocol have been made.

Purpose of the Study

The purpose of the study was to determine the effectiveness of the use of the IPOC on the processes and outcomes of patients undergoing elective carotid endarterectomy. The IPOC has been operational for more than 3 years, so the main purpose was to determine if the goals of the project had been met and maintained over time. Information gained from this study will be used to make appropriate modifications in the protocol and to evaluate quality of care and outcomes.

Research Questions

Two research questions were addressed in this study:

1. Are there differences in process and financial variables between the pre-IPOC, transition, and IPOC groups of patients undergoing elective carotid endarterectomy?

2. What are the complications and when did they occur in patients in the 3 groups?

Protection of Human Subjects

The nursing research committee at Orlando Regional Medical Center approved the proposal for the
Table 1 Summary of studies on outcomes of carotid endarterectomy

<table>
<thead>
<tr>
<th>Reference</th>
<th>N</th>
<th>Inclusion criteria</th>
<th>Anesthesia type</th>
<th>Length of stay</th>
<th>Financial</th>
<th>Same-day admissions</th>
<th>Complications</th>
<th>Angiography</th>
<th>Other important findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Williams et al.</td>
<td>186</td>
<td>Only 70% of control group were eligible for pathway</td>
<td>100% general</td>
<td>Targeted 3-day postoperative stay</td>
<td>Mean COH decreased from $12,881 to $9,701</td>
<td>Majority admitted for angiography and overnight stay</td>
<td>No difference in morbidity and mortality rates; readmissions decreased in post-pathway group</td>
<td>99% pre-operative</td>
<td>Findings inconclusive because of inadequate control group</td>
</tr>
<tr>
<td>Su and Carpenter</td>
<td>152</td>
<td>Elective, consecutive cases by same surgeon using same technique</td>
<td>100% general</td>
<td>Mean decreased from 6 to 3.3 days</td>
<td>Decrease in vascular study costs from $2,441 to $1,228</td>
<td>Preoperative hospitalization decreased from 100% to 21%; 54.6% same-day admissions</td>
<td>No difference in complications or readmission rates</td>
<td>From 100% to 10%</td>
<td>Target 6-hour length of stay in ICU</td>
</tr>
<tr>
<td>Blackburn and Neaton</td>
<td>185</td>
<td>Elective and emergent cases, excluded were cases including CABG</td>
<td>93% regional block</td>
<td>Decreased by 1.15 days</td>
<td>Cost per case decreased by $1,900</td>
<td>Typically admitted morning of surgery</td>
<td>No changes in morbidity and mortality</td>
<td>Not stated</td>
<td>Patients rarely admitted to the ICU; goal was for a 1 day stay; statistical analysis was not performed</td>
</tr>
<tr>
<td>Collier</td>
<td>186</td>
<td>Elective cases only</td>
<td>87% regional block</td>
<td>Mean 1.27 days</td>
<td>Cost savings &gt;$3,000 per patient compared with DRG reimbursement</td>
<td>Targeted same-day admissions</td>
<td>1.6% neurological complications; 10% ICU admissions, no readmissions, 1 death</td>
<td>Targeted outpatient arteriography on select basis</td>
<td>10% of patients were in ICU; regional block resulted in less postoperative hypertension; mean time in surgery, 48 minutes</td>
</tr>
<tr>
<td>Musser et al.</td>
<td>108</td>
<td>Elective cases only</td>
<td>Majority general</td>
<td>Decreased from 5.1 to 1.3 days</td>
<td>Decreased by $5,510 for pathway patients</td>
<td>Increased from 5% to 94%</td>
<td>No difference in mortality, complication, or readmission rates</td>
<td>Most did not have angiography preoperatively</td>
<td>Patients stayed in recovery room for 6 hours; had dedicated vascular ward</td>
</tr>
<tr>
<td>Kaufman et al.</td>
<td>163</td>
<td>Consecutive sample from 1 surgical group; 124 elective and 39 urgent</td>
<td>98% general; 2% cervical block</td>
<td>In second half, 61% discharged by postoperative day 1 and 87% by day 2</td>
<td>Not stated</td>
<td>76% admitted the day of surgery</td>
<td>13% general complication rate, 3 deaths, 14 early readmissions; surgeon had no relationship to complication rate</td>
<td>Not stated</td>
<td>Learning effect evaluated</td>
</tr>
<tr>
<td>Calligaro et al.</td>
<td>86</td>
<td>Elective cases only; emergent cases, inpatients, and transfers excluded</td>
<td>100% general</td>
<td>Reduced from 8.8 to 3.8 days</td>
<td>Annual cost savings of $1.27 million</td>
<td>Increased from 6.2% to 80%</td>
<td>No difference in mortality, morbidity, and readmission rates</td>
<td>Preoperative angiography done on outpatient basis</td>
<td>Had a dedicated vascular ward; some patients discharged from the ICU to home; early morning surgeries encouraged</td>
</tr>
</tbody>
</table>

CABG indicates coronary artery bypass grafting; COH, cost of hospitalization; DRG, diagnosis-related group; ICU, intensive care unit.
**Table 2** Key elements of the integrated plan of care for patients undergoing carotid endarterectomy

<table>
<thead>
<tr>
<th>Preoperative phase: preadmission testing/preoperative area</th>
<th>Immediate postoperative phase: postanesthesia care unit</th>
<th>Postoperative recovery phase: vascular thoracic unit</th>
<th>Discharge phase: vascular thoracic unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perform baseline neurological assessment and record findings</td>
<td>Assess incision for edema and/or hematoma</td>
<td>Perform same assessment as in postanesthesia care unit with hourly checks and documentation</td>
<td>Observe patient's ability to perform activities of daily living the morning after surgery</td>
</tr>
<tr>
<td>Measure blood pressure in both arms</td>
<td>Perform neurological assessment</td>
<td>Monitor blood pressure and control with drugs specified in protocol, same as was done in postanesthesia care unit</td>
<td>Assess patient as his or her condition indicates</td>
</tr>
<tr>
<td>Provide patient with educational materials</td>
<td>Evaluate patient's comfort and treat as needed</td>
<td></td>
<td>Remove arterial catheter if blood pressure has remained within parameters and no current intravenous vasoprotective or inotropic drugs being used to control blood pressure</td>
</tr>
<tr>
<td>Review course of hospitalization</td>
<td>Assess airway and oxygen levels</td>
<td>Have patient get out of bed and into a chair the night of surgery</td>
<td>Assess if assistance at home is needed and make appropriate referral with case manager</td>
</tr>
<tr>
<td>Review laboratory results and notify physician if values not within expected range</td>
<td>Use oxygen only when oxygen saturation &lt;93%</td>
<td>Offer diet of choice</td>
<td>Educate patient and patient's family with instructions about discharge and follow-up care with surgeon</td>
</tr>
<tr>
<td>Check pulse oximetry readings before administering oxygen</td>
<td>Monitor blood pressure with arterial catheter</td>
<td>Assess swallowing, Control nausea and vomiting</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Follow protocol for administering drugs to control blood pressure when it is out of desired range</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Control nausea and vomiting</td>
<td>Assess patient's ability to void. If patient needs urinary catheter, attempt to remove catheter as soon as feasible</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Stop administering oxygen as soon as parameters indicate it is feasible to do so</td>
<td></td>
</tr>
</tbody>
</table>

study in June 2000. Although the study was exempt from primary review by the institutional review board at the medical center, the study was approved with exempt status by the institutional review board at the University of Central Florida. Subjects in the study were not at risk, because only recorded data from available hospital databases were retrieved, and anonymity was maintained. Data for each patient were coded with a number, and all other identifying information was removed from the data. All data were maintained in a locked and secure place by the principal investigator.

**Methods**

Data on all patients admitted to the Orlando Regional Medical Center with the diagnosis of carotid occlusion without infarction who underwent elective carotid endarterectomy from October 1, 1995, through May 31, 2000, were retrieved from the hospital’s financial database system. These patients’ records were coded for diagnosis-related group 5, procedure code 38.12 (from the International Classification of Diseases, Ninth Revision), and admission diagnosis: carotid occlusion without infarction (433.10). Four vascular surgeons primarily performed this surgery at the institution and routinely used the protocol. Only those patients who had surgery performed by 1 of these 4 physicians were included because the care of these patients had most likely been managed by using the IPOC.

Patients admitted for other reasons who underwent carotid endarterectomy incidentally were excluded, because the protocol was for planned, elective cases. Patients who had a diagnosis of carotid occlusion with infarction were excluded. Of the patients who had more than a 1-day length of stay before surgery since August 1997, none were elective cases. In those cases, patients who were admitted more than 1 day before surgery had complex admission circumstances, involving a series of consultations and diagnostic tests, and were less likely to be elective, planned cases. Thus, all patients seen after August 1997 who had more than a 1-day preoperative stay were eliminated. For similar reasons, any patients who were transferred to the study facility for further evaluation and treatment were excluded.

Once the population was narrowed for inclusion, medical records of 72 patients who had a postoperative stay of more than 2 days were examined for complications, outcomes, and path of hospitalization, as were the
records of patients who died, regardless of the length of stay. Data from medical records were retrieved by 2 of the coinvestigators simultaneously for 24 patients whose preoperative length of stay was greater than 1 day. Interrater agreement was 100% (ie, both investigators were in complete agreement) about which patients to include and which to exclude. Another 12 patients’ records indicating a 1-day preoperative length of stay were evaluated by both investigators, and interrater agreement was 100% to include all 12 patients. The first 10 patients’ records that indicated postoperative lengths of stay of more than 2 days were reviewed to determine complications and course of hospitalization, again with 100% agreement between raters. Subsequent records were reviewed by 1 of the 2 investigators and recorded in a database. In order to ensure anonymity, all patients were assigned a code number, and no identifying information could be traced back to any patient.

Variables studied included demographics, type of anesthesia used (general or regional block), complications, and hospital discharge disposition. Complications were divided into major complications (myocardial infarction, stroke, respiratory failure, multiple organ dysfunction syndrome, and death) and other complications (dysrhythmias, further surgery for acute occlusion or bleeding, and angina). Financial and process variables included hospital costs, total length of stay, reasons for preoperative length of stay, admission to a critical care unit, and use of preoperative angiography.

Assumptions in the study were that before implementation of the IPOC, patients who had carotid endarterectomy were not managed according to any protocol and that those patients who had the procedure after implementation of the IPOC would be managed by using the IPOC if they met the criteria. An initial review of patients’ records in the first year of implementation of the IPOC indicated an 80% compliance with use of the IPOC. The current compliance rate for patients who meet the criteria for use of the IPOC is nearly 100%.

Analysis of Data
The study had a descriptive, comparative design. Three comparative groups were formed for purposes of analysis: (1) pre-IPOC: patients admitted for carotid endarterectomy during the year preceding implementation of the pathway (October 1, 1995, to September 30, 1996), (2) transition: patients admitted during the first 6 months of implementation of the pathway (October 1, 1996, to March 31, 1997), and (3) IPOC: patients admitted for carotid endarterectomy after the transition period (April 1, 1997, to May 31, 2000). Descriptive statistics were used to summarize data in the 3 groups. Parametric and nonparametric statistics were used to determine differences between the groups. Statistical significance was set at $P \leq .05$.

Results
After establishing which patients would be included, we retrieved as many data as possible from the hospital’s financial database. Medical records were reviewed for patients who stayed in the hospital more than 2 days, died, or were admitted to the ICU, as described in the “Methods” section. A total of 783 patients were included: 129 in the pre-IPOC group, 66 in the transition group, and 588 in the IPOC group.

Demographics of the total sample are summarized in Table 3. The typical candidate was a 70-year-old man who was admitted on the day of surgery, had an uncomplicated course of hospitalization, and was discharged home the day after surgery. Mean total length of stay for all patients was 1.92 days, and mean hospital costs were $5815 per case. A total of 689 patients were admitted on the day of surgery.

The 3 groups were analyzed to determine differences by sex and age. Chi-square analysis revealed no difference in sex or type of anesthesia used between groups. Analysis of variance indicated no difference between groups by age. Thus, the types of patients in each group were similar.

Answers to the research questions are summarized in the following paragraphs.

Process and Financial Variables
Lengths of stay were compared between groups. The mean length of stay was 2.93 days for pre-IPOC patients, 2.12 days for transition patients, and 1.68 days for IPOC patients. Analysis of variance indicated a significant difference in length of stay between groups ($P = .001$). A post hoc Tukey honestly significant difference test indicated a significant difference in length of stay between pre-IPOC and IPOC phases ($P = .001$) but not between the pre-IPOC and transition phases (Figure 1).

Analysis of variance also indicated that preoperative length of stay differed significantly between groups ($P < .001$). Mean preoperative length of stay was 0.29 days in the pre-IPOC phase, and 0.06 and 0.08 days in the transition and IPOC phases, respectively. A post hoc Tukey test revealed differences between the pre-IPOC phase and both the transition and IPOC phases ($P < .001$).

One component of the protocol was to reduce the number of admissions to the ICU, promote an increase in use of the step-down unit, and avoid overnight stays in the postanesthesia care unit (PACU). Before implementation of the IPOC, most patients were sent to the ICU. In our analysis, 99 (77%) of 129 patients were
admitted to the ICU at some time during hospitalization during the pre-IPOC phase. Eighteen patients (14%) were sent to general surgical wards, 4 (3%) stayed overnight in the PACU and were discharged to home, and 6 (5%) were admitted to the step-down unit. During the transition phase, 16 (24%) of 66 patients were admitted to the ICU, 45 (68%) were admitted to the step-down area, and 4 (6%) stayed overnight in the PACU. During the IPOC phase, 437 (74%) of 588 patients were primarily admitted to the step-down unit, 53 (9%) had an ICU stay during hospitalization, 37 (6%) stayed overnight in the PACU, and 61 (10%) received care in a general care unit or cardiology unit (Figure 2). Since the opening of the vascular thoracic unit in June 1999, 189 (94%) of 201 patients have been successfully cared for in a step-down unit. Only 7 patients were admitted to the ICU during that period.

Hospital costs were analyzed by group and are determined in the financial database by using a ratio of costs to charges. Mean costs were $7798 per case for the pre-IPOC group, $5750 for the transition group, and $5387 for the IPOC group. Analysis of variance indicated a difference between groups by costs ($P<.001). A Tukey post hoc test revealed differences in costs between pre-IPOC and IPOC phases ($P<.001) but no difference between pre-IPOC and transition groups. No significant differences in hospital charges were found between groups. Figure 1 summarizes the changes in hospital costs and length of stay between groups.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex, No. (%) of patients</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>448 (57)</td>
</tr>
<tr>
<td>Female</td>
<td>335 (43)</td>
</tr>
<tr>
<td>Age, years</td>
<td></td>
</tr>
<tr>
<td>Mean (SD)</td>
<td>69.84 (8.6)</td>
</tr>
<tr>
<td>Median</td>
<td>70</td>
</tr>
<tr>
<td>Mode</td>
<td>69</td>
</tr>
<tr>
<td>Range</td>
<td>41-93</td>
</tr>
<tr>
<td>Total length of stay, days</td>
<td></td>
</tr>
<tr>
<td>Mean (SD)</td>
<td>1.92 (3.46)</td>
</tr>
<tr>
<td>Median</td>
<td>1</td>
</tr>
<tr>
<td>Mode</td>
<td>1</td>
</tr>
<tr>
<td>Range</td>
<td>1-73</td>
</tr>
<tr>
<td>Preoperative length of stay, days</td>
<td></td>
</tr>
<tr>
<td>Mean (SD)</td>
<td>0.12 (0.33)</td>
</tr>
<tr>
<td>Median</td>
<td>0</td>
</tr>
<tr>
<td>Mode</td>
<td>0</td>
</tr>
<tr>
<td>No. (%) of patients with 0 days</td>
<td>689 (88)</td>
</tr>
<tr>
<td>No. (%) of patients with 1 day</td>
<td>94 (12)</td>
</tr>
<tr>
<td>Hospital costs, $US per case</td>
<td></td>
</tr>
<tr>
<td>Mean (SD)</td>
<td>5815 (6151)</td>
</tr>
<tr>
<td>Median</td>
<td>4694</td>
</tr>
<tr>
<td>Mode</td>
<td>2582</td>
</tr>
<tr>
<td>Anesthesia type, No. (%) of patients</td>
<td></td>
</tr>
<tr>
<td>General</td>
<td>468 (60)</td>
</tr>
<tr>
<td>Regional block</td>
<td>315 (40)</td>
</tr>
<tr>
<td>Discharge disposition, No. (%) of patients</td>
<td></td>
</tr>
<tr>
<td>Home</td>
<td>768 (98)</td>
</tr>
<tr>
<td>Skilled nursing or rehabilitation</td>
<td>13 (1.7)</td>
</tr>
<tr>
<td>Died</td>
<td>2 (0.3)</td>
</tr>
</tbody>
</table>

**Figure 1** Mean length of stay and hospital costs by group.

IPOC indicates integrated plan of care.

**Figure 2** Percentage of patients admitted to various units after surgery.

IPOC indicates integrated plan of care; PACU, postanesthesia care unit.

<table>
<thead>
<tr>
<th>Group</th>
<th>Step-down unit</th>
<th>PACU</th>
<th>Intensive care unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-IPOC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transition Group</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IPOC</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3 Demographics of the total sample (N = 783)
Analysis was done to determine the use of preoperative cerebral angiography during hospitalization for carotid endarterectomy. Thirty-two percent of patients underwent cerebral angiography before surgery in the pre-IPOC phase, 11% in the transition phase, and 4% in the IPOC phase. Chi-square analysis indicated a difference between groups for the rate of use of cerebral angiography (P<0.001). Among the total group of 783 patients, 5 were admitted for reasons other than angiography, including diagnostic clearance (eg, cardiac testing) or preoperative treatment of comorbid conditions.

All patients’ records were reviewed to determine disposition at discharge. Only 13 of the 783 patients were discharged to a skilled nursing facility or other intermediate care facility for further rehabilitative care. The remainder (98%) were discharged to their homes with either self-care or home health referral. The records of patients who stayed in the hospital for reasons unrelated to complications were analyzed further.

Complications

Medical records of 72 patients who had a postoperative length of stay greater than 2 days were reviewed to determine what complications occurred during hospitalization. Complications were divided into major complications and other events/complications that led to prolonged hospitalization. The time to onset and the location of the patient at the time of onset of the complications were recorded. The small number of complications precluded inferential statistical analysis. Percentages and descriptive statistics are presented.

In the pre-IPOC group, 2 (1.6%) of 129 patients had a myocardial infarction. Mean time of onset of myocardial infarction in this group was 5.6 hours, and the patients were located in the PACU and the ICU. Only 1 patient (0.8%) had a stroke 14 hours after surgery while in the ICU. Three patients (2.3%) went into respiratory failure; 2 while in the ICU, with a mean onset of 33 hours, and 1 from the general surgery unit, with onset 120 hours after surgery. Of these 3 patients, 2 required further rehabilitative hospitalization. No deaths occurred during this period.

In the transitional group, the only major complication observed was myocardial infarction in 5 (7.6%) of the 66 patients. The time to onset for myocardial infarction in this group was 13.8 hours postoperatively. In 4 patients, the infarction occurred in the ICU, and 1 of these 4 patients died. The surviving 4 patients were discharged to home from the hospital.

In the IPOC group, 9 (1.5%) of 588 patients had a myocardial infarction. The mean time of onset was 24 hours after surgery (range, 4.5-48 hours). Seven of those patients were in the step-down unit at the onset of the myocardial infarction. Of these 7 patients, 2 later had coronary artery bypass surgery, and 2 had concomitant respiratory failure. Of the 9 patients, all were discharged to home from the hospital except for 1 patient, who went to a rehabilitation facility. Five patients in the IPOC group (1%) had a stroke. The time of onset for postoperative stroke varied from 0.2 to 20 hours after surgery, with a mean onset of 7.24 hours. Patients were in the PACU, step-down unit, and the ICU at the time the stroke occurred. Of the 5 patients, 3 went to a rehabilitation facility after discharge, and the other 2 went home. Six patients (1%) experienced respiratory failure after surgery, 2 of the 6 also had a myocardial infarction, as just mentioned. The mean onset of respiratory failure in 5 of the 6 patients was 6.69 hours after surgery. One patient had a late onset of respiratory failure at 144 hours after surgery. One death occurred during this period. The patient who died experienced a sudden cardiopulmonary arrest. The causes leading to the death were unknown, because the patient’s postoperative course had been uncomplicated.

The prevalence of major complications of myocardial infarction and stroke combined was 2.32% in the pre-IPOC group and 2.38% in the IPOC group. Thus, these complications occurred at similar rates with or without IPOC management.

Other complications were compared among the 3 groups. These complications included undergoing further surgery for bleeding or occlusion, dysrhythmias, arterial blood pressures requiring treatment, pneumonia, and renal insufficiency. Table 4 summarizes other complications and their timing of onset. Many patients who had 1 complication had another, concomitant complication. Five patients with other complications were discharged to skilled nursing facilities or rehabilitation units. Each of the 5 patients had either respiratory failure or a cerebrovascular accident along with the other complication, namely, hypertension requiring treatment and pneumonia. Along with the major complications, these other complications were thought to have contributed to hospitalization of more than 2 days.

Inspection of the medical records indicated a number of reasons other than complications for an increase in the length of stay in the hospital. No specific reasons were identifiable for 5 patients in the total series. Three patients remained in the hospital for continued treatment for a comorbid condition. Three patients stayed more than 2 days because of a lack of home support. Four patients stayed for other surgical procedures. Two remained for diagnosis of another condition. One patient stayed because the patient could not get out of bed without help. Finally, 1 patient remained in the hospital because of a hematoma, which did not require surgery.
Discussion

The findings from this study indicate that use of the IPOC for carotid endarterectomy was effective in reducing hospital costs and length of stay during the phases of implementation. Some costs were improved by reducing preoperative length of stay and use of angiography. No differences were found in the use of cerebral angiography between the transition and IPOC phases. However, significant changes in this practice occurred from the pre-IPOC phase to the transition phase. Thus, most of the changes with respect to angiography occurred early in the initiative. Our findings of a reduction in hospital costs and length of stay are consistent with the findings of other studies.3-9,12

A potential contributing factor in reducing hospital costs for carotid endarterectomy is the anticipated reimbursement of funding to the hospital. Because the typical patient undergoing this procedure is nearly 70 years old, most patients have the costs of the procedure covered by the Medicare system. The mean national payment by Medicare for this procedure has decreased from $6319 in 1996 to $5931 in 2000, a change of $388 per case.13 In our study, the mean hospital cost was reduced to $5387 in the IPOC period, from $7798 per case in the pre-IPOC period. This reduction indicates a shift from a potential loss of revenue to savings for the institution in excess of $1.5 million since implementation of the IPOC. This trend will be even more helpful if further cuts in federal reimbursement occur.

Table 4 Other complications of carotid endarterectomy requiring extended hospitalization for more than 2 days

<table>
<thead>
<tr>
<th>Complication</th>
<th>Pre-IPOC (n = 129)</th>
<th>Transition (n = 66)</th>
<th>IPOC (n = 588)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Further surgery after occlusion or rebleeding</td>
<td>2</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Dysrhythmias</td>
<td>1</td>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td>Angina</td>
<td>2</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Hypotension with treatment</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Hypertension with treatment</td>
<td>0</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>3</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Acute renal insufficiency</td>
<td>1</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Electrolyte imbalance</td>
<td>0</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Fever</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Alcohol withdrawal</td>
<td>2</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Pulmonary edema, congestive heart failure</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Nausea and vomiting</td>
<td>0</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total, No. (%) of patients</strong></td>
<td><strong>12 (9)</strong></td>
<td><strong>13 (20)</strong></td>
<td><strong>34 (6)</strong></td>
</tr>
</tbody>
</table>

IPOC indicates integrated plan of care.

A potential contributing factor in reducing hospital costs was the development of the step-down unit for postoperative monitoring of patients after carotid endarterectomy. Historically, patients who had this procedure were cared for in the ICU, and ICU care is associated with higher costs. The step-down unit is specialized for the care of vascular surgery patients. The staff on the unit have grown accustomed to using protocols and IPOCs to direct patients’ care. This factor, along with support from the leadership team and training provided by the clinical nurse specialist and nurse clinician on the unit, probably enhanced both financial and clinical outcomes associated with use of the protocol.

Another important factor with regard to hospital costs for carotid endarterectomy is the anticipated reimbursement of funding to the hospital. Because the typical patient undergoing this procedure is nearly 70 years old, most patients have the costs of the procedure covered by the Medicare system. The mean national payment by Medicare for this procedure has decreased from $6319 in 1996 to $5931 in 2000, a change of $388 per case.13 In our study, the mean hospital cost was reduced to $5387 in the IPOC period, from $7798 per case in the pre-IPOC period. This reduction indicates a shift from a potential loss of revenue to savings for the institution in excess of $1.5 million since implementation of the IPOC. This trend will be even more helpful if further cuts in federal reimbursement occur.

The complication rate in our sample of patients is consistent with nationalized norms for carotid endarterectomy. The major complications of myocardial infarct and stroke between the pre-IPOC phase and the IPOC phase did not differ, and only 2 postop-
operative deaths occurred among all the patients undergoing carotid endarterectomy. Thus, the quality of patients’ outcomes was not sacrificed as a result of the new protocol. These findings are consistent with recent reports from facilities that use similar clinical pathways.\textsuperscript{3,6,10,14} Because a transient increase occurred in the number of patients who had a myocardial infarction and other complications during the transition phase, emphasis on enhanced vigilance during a change in practice may be warranted. The finding that 98% of patients were discharged to their homes indicates successful movement of patients through the system, with transition to home care and reduced need for readmission to the hospital.

Another goal in the study was to evaluate the time until development of postoperative complications. Interestingly, myocardial infarction mostly occurred after the immediate postoperative period, when patients were in a step-down unit. Stroke occurred either early in the PACU stay or hours later, in the step-down unit. With the current protocol, patients typically spend 3 hours in the PACU before they are admitted to the vascular surgery unit. The purpose of this period is to observe for early postoperative complications that might require immediate surgical intervention, including thrombosis of the graft or rapidly expanding hematoma. Additionally, hemodynamic stability and determination of the need for ICU admission are addressed. In our study, most patients had complications well before the 3-hour observational window and were being correctly managed at that stage. Patients’ charges for the stay in the PACU are time oriented, and the ability to maintain sufficient flow of patients in a recovery area is an important issue to consider when maintaining patients in this area of care. On the basis of our findings, we recommend that the observational time in PACU be reduced to 2 hours with specific instructions for continued observation for major complications in the step-down unit. We hope that this adjustment will improve the cost-effectiveness associated with use of the pathway and movement of surgical patients through the facility.

Another implication of the time of onset of myocardial infarction is that myocardial infarction must be seriously considered in any patient experiencing any indicators for myocardial ischemia after the initial postoperative period. Many patients who have carotid endarterectomy have a history of cardiac comorbid conditions and are at risk for cardiac complications. Maintaining a high index of suspicion and focusing on early identification of patients at risk may be instrumental in appropriate and timely management and prevention of cardiac complications.

One limitation of this study is that it was a retrospective review of information retrieved for analysis from a hospital’s financial database and a review of medical records. Thus, important details may have been lost. Another limitation is that 30-day mortality due to carotid endarterectomy was not included. This limitation was not addressed because retrieving this information was not feasible and no databases were available for this retrospective study. In future studies, 30-day mortality may be a helpful parameter to monitor.

**Summary**

The IPOC for carotid endarterectomy was successfully integrated into patients’ care and was effective over time. The use of a systematic clinical protocol reduced hospital costs and length of stay and improved transfer of patients within the hospital. Using the protocol did not result in changes in the quality of patients’ outcomes, and most patients were discharged to home without complications. Our findings support results from previous reports of similar initiatives for the management of patients undergoing carotid endarterectomy, thus supporting further initiatives of this type in comparable populations of patients.

**ACKNOWLEDGMENT**

We thank E. Angela Capillary, systems analyst for the Orlando Regional Healthcare System, for her assistance.

**REFERENCES**

CE Test Instructions

To receive CE credit for this test (ID# A021103), mark your answers on the form below, complete the enrollment information, and submit it with the $12 processing fee (payable in US funds) to American Association of Critical-Care Nurses (AACN). Answer forms must be postmarked by May 1, 2004. Within 3 to 4 weeks of AACN receiving your test form, you will receive an AACN CE certificate.

This continuing education program is provided by AACN, which is accredited as a provider of continuing education in nursing by the American Nurses Credentialing Center’s Commission on Accreditation. AACN has been approved as a provider of continuing education by the State Boards of Nursing of Alabama (#ABNP0062), California (01036), Florida (#FBN2464), Iowa (#332), Louisiana (#ABN12), Nevada, and Colorado. AACN programming meets the standards for most other states requiring mandatory continuing education credit for relicensure.

CE Test Form

The Effect of a Critical Pathway on Patients’ Outcomes After Carotid Endarterectomy

Objectives
1. Recognize indications and common risks associated with carotid endarterectomy
2. Describe the purpose and goals in establishing an integrated plan of care
3. Delineate study findings regarding length of stay, hospital costs, and in-hospital transfers

Mark your answers clearly in the appropriate box. There is only one correct answer. You may photocopy this form.

Program evaluation

Objective 1 was met
Objective 2 was met
Objective 3 was met
The content was appropriate
My expectations were met
This method of CE is effective for this content
The level of difficulty of this test was:
To complete this program, it took me __________ hours/minutes.

Name ____________________________________________________________________________
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City ___________________ State ___ ZIP__________
E-mail address _________________________________________________________________
AACN member number ________________________________

I would like to receive my certificate via e-mail (check box) ☐

Mail this entire page to: AACN, 101 Columbia, Aliso Viejo, CA 92656, (800) 899-2226
1. Which one of the following best describes the purpose of a clinical pathway or protocol?
   a. To describe the most expedient way to discharge the patient
   b. To provide a framework to coordinate care for a specific population of patients
   c. To delineate which patients need to go to the ICU postoperatively
   d. To increase length of stay in a specific population of patients

2. Which one of the following statements regarding carotid endarterectomy is true?
   a. It is the removal of plaque from the inner lumen of the carotid artery.
   b. It is indicated in most patients with greater than 70% stenosis of the carotid artery.
   c. It is the most frequently performed vascular surgical procedure in the United States.
   d. All of the above

3. Which one of the following is not a major complication associated with the carotid endarterectomy surgical procedure?
   a. Myocardial infarction
   b. Stroke
   c. Diabetes mellitus
   d. Pulmonary complications

4. Which of the following are desired outcomes of most protocols for carotid endarterectomy?
   a. Decreased routine preoperative angiographies
   b. Use of the ICU for selective rather than routine patient admission
   c. Decreased preoperative and postoperative lengths of hospital stay
   d. All of the above

5. What was the major emphasis behind the integrated plan of care (IPOC) instituted in this study?
   a. Address practice issues across the continuum of hospital care
   b. Streamline care with coordinated efforts at maintaining quality
   c. Address staffing issues related to patient care
   d. A and B only

6. Following the implementation of the IPOC for the carotid endarterectomy patient, what is the current compliance rate for patients who meet the criteria for its use?
   a. 70%
   b. 80%
   c. 90%
   d. 100%

7. Which one of the following demographics best describes the most common subject in this study?
   a. 60-year-old woman with regional anesthesia discharged to a skilled nursing facility
   b. 70-year-old man with general anesthesia discharged home
   c. 88-year-old man with regional anesthesia discharged home
   d. 55-year-old woman with general anesthesia with complications leading to death.

8. Which one of the following is true regarding the complications of myocardial infarction and stroke in the pre-IPOC group and the IPOC group?
   a. Complications occurred at similar rates with or without IPOC management.
   b. Complications occurred more frequently in the IPOC group.
   c. Complications occurred more frequently in the pre-IPOC group.
   d. None of the above is true

9. Which one of the following is true regarding length of hospital stay in the patient managed with IPOC for carotid endarterectomy?
   a. Length of ICU stay was increased in this population
   b. Length of hospital stay was decreased in this population
   c. Length of hospital stay was increased in this population
   d. There was no change in length of stay for patients utilizing the IPOC

10. Utilizing the key elements of the IPOC for patients undergoing carotid endarterectomy, which one of the following nursing activities is recommended in all phases of patient care (preoperative, immediate postoperative, and postoperative recovery stages)?
    a. Perform and document neurological assessment
    b. Offer diet of choice
    c. Have patient get out of bed and into a chair
    d. Provide patient with educational materials

11. Which one of the following is not recommended in the discharge phase of the IPOC for the carotid endarterectomy patient?
    a. Observe patient’s ability to perform activities of daily living
    b. Educate patient and family with discharge and follow-up instructions
    c. Encourage strict bed rest with head of bed flat
    d. Assess if assistance at home is indicated
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