

# Postoperative Care After Elective Endovascular Treatment of Unruptured Intracranial Aneurysms: Where Matters Less Than What

Martin Smith, MBBS, FRCA, FFICM

Endovascular techniques for the treatment of intracranial aneurysms are minimally invasive and relatively safe, but do have potential for major cerebrovascular and other complications.<sup>1</sup> Although intraprocedural complications such as thromboembolism and aneurysm rupture are dealt with as they occur, they can lead to delayed ischemic events. Other complications, such as bleeding or access-related hematoma, usually occur in a delayed fashion some hours after the procedure. It is for these reasons that many centers routinely admit all patients to an intensive care unit (ICU) after intracranial endovascular procedures, including elective interventions. The justification for such practice is that it might reduce the incidence of early postoperative complications by proactive management or minimize the potential adverse outcome effects by their early identification and treatment. However, the benefits of routine ICU admission after uncomplicated endovascular treatment of an unruptured intracranial aneurysm are unproven, and such practice is not universal.

Advances in neuroimaging and endovascular techniques over the past 2 decades have led to an increase in the number of unruptured aneurysms treated by the endovascular route,<sup>2</sup> bringing new pressures on health care resources and additional costs.<sup>3</sup> Postoperative care contributes to inpatient health care costs but variably so, with management on an ICU being most expensive.<sup>4</sup> The daily cost of ICU care is 3 to 5 times higher than care on a surgical ward,<sup>5</sup> and this is true even for anticipated “short” postoperative stays because daily costs for nonventilated patients are highest in the first 2 days after ICU admission.<sup>6</sup> As well as being expensive, ICU resources are also limited in many countries.<sup>7</sup> There is considerable pressure to minimize ICU overutilization in all

health care systems, and the financial implications of doing so are substantial.<sup>8</sup> Therefore, the practice of routine ICU admission after elective intracranial interventions is being challenged and subject to cost-benefit analysis.<sup>9</sup> Identifying which patients actually require intensive care is relevant not only to health care managers and policy makers, but also to patients and clinicians.

Although admission of patients to the ICU after elective craniotomy remains a standard practice in some centers, it was noted as early as 1998 that active intervention is rarely required and that most patients are managed on the ICU for 1 day or less.<sup>10</sup> The majority of elective neurosurgical patients admitted to the ICU undergo intensive “monitoring” (usually only clinical neurologic assessment) rather than intensive “care”<sup>11</sup> and, in one study, the administration of IV analgesia was the most common and intensive “intervention” beyond 4 hours after ICU admission.<sup>12</sup> Because postoperative ICU admission is resource intensive, it should be limited to those who require, and who will derive benefit from, the levels of monitoring and intervention that can be provided only in an ICU. Assigning patients to alternative (and possibly more appropriate) levels of care results in more efficient use of hospital resources.<sup>13</sup> In a 2003 study, immediate transfer to a neurosurgical ward after elective craniotomy decreased average hospital length of stay by 3 days, with estimated cost savings of \$4026 per patient.<sup>9</sup> As well as being cost-effective, selective rather than routine admission of elective neurosurgical patients to an ICU has been shown to be safe,<sup>14</sup> and such practice is already commonplace in many units around the world. In the United Kingdom, some centers have even performed carefully selected craniotomies for tumor resection on a day-surgery basis,<sup>15</sup> and although such findings cannot be extrapolated more widely, they do challenge existing models of care. It seems at least possible that some of the patients in this United Kingdom case series would elsewhere have been admitted to an ICU rather than discharged from the hospital.

Whether evidence supporting selective rather than routine ICU admission after elective intracranial surgery is transferable to uncomplicated elective endovascular treatment of unruptured intracranial aneurysms is not clear, and, therefore, whether all, none, or a selected group of such patients can be safely managed outside an ICU is uncertain. In this issue of *Anesthesia & Analgesia*, Eisen et al.<sup>16</sup> attempt to address this issue. In a retrospective case

From the Department of Neuroanaesthesia and Neurocritical Care, The National Hospital for Neurology and Neurosurgery, University College London Hospitals; and UCLH National Institute for Health Research Biomedical Research Centre, London, United Kingdom.

Accepted for publication February 27, 2015.

Funding: Martin Smith is funded, in part, by the UCLH National Institute for Health Research Biomedical Research Centre.

The author declares no conflicts of interest.

Reprints will not be available from the author.

Address correspondence to Martin Smith, MBBS, FRCA, FFICM, Department of Neuroanaesthesia and Neurocritical Care, The National Hospital for Neurology and Neurosurgery, University College London Hospitals, Queen Sq., London WC1N 3BG, United Kingdom. Address e-mail to martin.smith@ucl.ac.uk.

Copyright © 2015 International Anesthesia Research Society  
DOI: 10.1213/ANE.0000000000000767

note review, the authors examined the outcomes of patients who underwent elective endovascular treatment of unruptured intracranial aneurysms in a single center over a 3-year period. The institution's practice evolved during this period from one of routine postprocedure admission of all patients to the ICU to planned admission of selected patients to a postanesthesia care unit (PACU). Adverse perioperative neurologic event rates did not change over the 3 years, despite planned ICU admission rates decreasing from 100% to 15%. The majority (95%) of the 131 patients first admitted to the PACU were transferred to a neurosurgical ward after a median PACU stay of 1.3 hours. Eight PACU patients developed a new adverse neurologic event, but 4 of these events were recognized within 1 hour of the procedure while the patients were still in the PACU. Two patients were immediately transferred to the ICU, and 2 were transferred after an intracranial intervention. Two other patients were transferred to the ICU directly from the PACU but for nonneurologic reasons (respiratory failure requiring reintubation, and the need for continued intubation because of anticoagulation-related epistaxis). Four patients initially managed on the PACU developed neurologic events after transfer to the neurosurgical ward, between 3 and 39 hours after the procedure, but only one required secondary transfer to the ICU. In comparison, 3 of 8 new neurologic events in patients initially admitted to the ICU occurred after discharge from the ICU to the neurosurgical ward. In summary, this study found no evidence that the diagnosis of new postoperative neurologic events in patients first admitted to the PACU was substantively delayed compared with those admitted to the ICU or that their outcome was adversely affected.

A recent study examining the timing and nature of postprocedure complications after uncomplicated endovascular aneurysm repair gives further insights into decisions about postoperative monitoring and management.<sup>17</sup> Twenty-seven (4.0%) of 687 endovascular interventions were associated with a postprocedural complication, including hemorrhagic and ischemic stroke, cardiac events, and retroperitoneal and groin hematomas. The majority of these (74%) occurred within the first 4 hours after the procedure, and those that occurred later were relatively minor and required no treatment. These findings are reinforced by 2 other studies.<sup>18,19</sup> In one, 65% of 200 consecutive endovascular procedures for unruptured intracranial aneurysms were triaged to non-ICU ward-based care determined by preexisting medical comorbidities, intraoperative findings, and absence of major intra-procedural complications.<sup>18</sup> In this study, 15 of 18 adverse events were recognized during the procedure and dealt with immediately, and 2 others occurred within the first 24 hours postprocedure. Only one patient required a change of planned postoperative care, and there were no complications in patients triaged for elective ICU admission because of difficult aneurysm morphology or the use of investigational devices. This led the authors to suggest that a more aggressive policy of admission to a neurosurgical ward after a period of intensive observation might be appropriate.

Choice of postoperative care location is driven primarily by the availability of (clinical) neurologic monitoring and interventions such as arterial blood pressure control that must be provided in the first few hours after endovascular

interventions. The availability of sufficient and appropriately trained staff to monitor neurologic status continuously and the ability for rapid transfer in the event of deterioration are therefore more important than the designation of the care location. In the study by Eisen et al., there is little difference between the level of care provided in the PACU and ICU. In many ways, the PACU in their institution appears to operate as a short-term ICU "equivalent" with staffing levels and facilities that are not universally available in intermediate care locations elsewhere. Thus, although the authors have demonstrated that postoperative management in their PACU is safe, they have not determined (nor did they set out to do so) its relative cost-effectiveness compared with ICU care. This is an important next step.

The study by Eisen et al. adds to accumulating evidence that the majority of patients undergoing elective endovascular treatment of unruptured cerebral aneurysms who do not experience intraoperative complications can be safely managed without routine ICU admission so long as frequent and reliable neurologic assessment is available in the early postprocedure period. This is already the norm in some centers and countries, and although this has been driven in part by resource limitations, it is reassuring that such practice appears to be safe in carefully selected patients. Adequately powered prospective studies are now required to determine with certainty which patients can be safely managed on a neurosurgical ward after a short period of intensive observation after endovascular treatment of an unruptured intracranial aneurysm, and which might benefit from admission to an ICU. Such decisions must ultimately be driven by safety and not just cost. ■

#### DISCLOSURES

**Name:** Martin Smith, MBBS, FRCA, FFICM.

**Contribution:** This author conceived and wrote this Editorial.

**Attestation:** Martin Smith approved the final manuscript.

**This manuscript was handled by:** Gregory J. Crosby, MD.

#### REFERENCES

- Orrù E, Roccatagliata L, Cester G, Causin F, Castellan L. Complications of endovascular treatment of cerebral aneurysms. *Eur J Radiol* 2013;82:1653–8
- Andaluz N, Zuccarello M. Recent trends in the treatment of cerebral aneurysms: analysis of a nationwide inpatient database. *J Neurosurg* 2008;108:1163–9
- Brinjikji W, Kallmes DF, Lanzino G, Cloft HJ. Hospitalization costs for endovascular and surgical treatment of unruptured cerebral aneurysms in the United States are substantially higher than Medicare payments. *AJNR Am J Neuroradiol* 2012;33:49–51
- Halpern NA, Pastores SM. Critical care medicine in the United States 2000-2005: an analysis of bed numbers, occupancy rates, payer mix, and costs. *Crit Care Med* 2010;38:65–71
- Milbrandt EB, Kersten A, Rahim MT, Drenszizov TT, Clermont G, Cooper LM, Angus DC, Linde-Zwirble WT. Growth of intensive care unit resource use and its estimated cost in Medicare. *Crit Care Med* 2008;36:2504–10
- Dasta JF, McLaughlin TP, Mody SH, Piech CT. Daily cost of an intensive care unit day: the contribution of mechanical ventilation. *Crit Care Med* 2005;33:1266–71
- Ridley S, Morris S. Cost effectiveness of adult intensive care in the UK. *Anaesthesia* 2007;62:547–54
- Ward NS, Teno JM, Curtis JR, Rubenfeld GD, Levy MM. Perceptions of cost constraints, resource limitations, and rationing in United States intensive care units: results of a national survey. *Crit Care Med* 2008;36:471–6

9. Beauregard CL, Friedman WA. Routine use of postoperative ICU care for elective craniotomy: a cost-benefit analysis. *Surg Neurol* 2003;60:483–9
10. Nitahara JA, Valencia M, Bronstein MA. Medical case management after laminectomy or craniotomy: do all patients benefit from admission to the intensive care unit? *Neurosurg Focus* 1998;5:e4
11. Zimmerman JE, Junker CD, Becker RB, Draper EA, Wagner DP, Knaus WA. Neurological intensive care admissions: identifying candidates for intermediate care and the services they receive. *Neurosurgery* 1998;42:91–101
12. Ziai WC, Varelas PN, Zeger SL, Mirski MA, Ulatowski JA. Neurologic intensive care resource use after brain tumor surgery: an analysis of indications and alternative strategies. *Crit Care Med* 2003;31:2782–7
13. Hanak BW, Walcott BP, Nahed BV, Muzikansky A, Mian MK, Kimberly WT, Curry WT. Postoperative intensive care unit requirements after elective craniotomy. *World Neurosurg* 2014;81:165–72
14. Bui JQ, Mendis RL, van Gelder JM, Sheridan MM, Wright KM, Jaeger M. Is postoperative intensive care unit admission a prerequisite for elective craniotomy? *J Neurosurg* 2011;115:1236–41
15. Grundy PL, Weidmann C, Bernstein M. Day-case neurosurgery for brain tumours: the early United Kingdom experience. *Br J Neurosurg* 2008;22:360–7
16. Eisen SH, Hindman BJ, Bayman EO, Dexter F, Hasan DM. Elective endovascular treatment of unruptured intracranial aneurysms: a management case series of patient outcomes after institutional change to admit patients principally to postanesthesia care unit rather than to intensive care. *Anesth Analg* 2015;121:188–97
17. Arias EJ, Patel B, Cross DT 3rd, Moran CJ, Dacey RG Jr, Zipfel GJ, Derdeyn CP. Timing and nature of in-house postoperative events following uncomplicated elective endovascular aneurysm treatment. *J Neurosurg* 2014;121:1063–70
18. Burrows AM, Rabinstein AA, Cloft HJ, Kallmes DF, Lanzino G. Are routine intensive care admissions needed after endovascular treatment of unruptured aneurysms? *AJNR Am J Neuroradiol* 2013;34:2199–201
19. Niskanen M, Koivisto T, Rinne J, Ronkainen A, Pirskanen S, Saari T, Vanninen R. Complications and postoperative care in patients undergoing treatment for unruptured intracranial aneurysms. *J Neurosurg Anesthesiol* 2005;17:100–5