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**CLINICAL RESEARCH**

# Use of second generation supraglottic airway device for endovascular treatment of unruptured intracranial aneurysms: a retrospective cohort

Paola Hurtado[a], Marta Garcia-Orellana[a], Sergi Amaro[b], Enrique Carrero[a], Federico Zarco[c], Anna Lopez[a], Neus Fabregas[a], Ricard Valero [a],*

[a] *Hospital Clínic de Barcelona, Anaesthesiology Department, Barcelona, Spain*
[b] *Hospital Clínic de Barcelona, Neurology Department, Barcelona, Spain*
[c] *Hospital Clínic de Barcelona, Radiology Department, Barcelona, Spain*

**Abstract**
*Background:* We aimed to assess the feasibility of using supraglottic devices as an alternative to orotracheal intubation for airway management during anesthesia for endovascular treatment of unruptured intracranial aneurisms in our department over a nine-year period.
*Methods:* Retrospective single center analysis of cases (2010−2018). Primary outcomes: airway management (supraglottic device repositioning, need for switch to orotracheal intubation, airway complications). Secondary outcomes: aneurysm complexity, history of subarachnoid hemorrhage, hemodynamic monitoring, and perioperative complications.
*Results:* We included 187 patients in two groups: supraglottic device 130 (69.5%) and orotracheal intubation 57 (30.5%). No adverse incidents were recorded in 97% of the cases. Three supraglottic device patients required supraglottic device repositioning and 1 supraglottic device patient required orotracheal intubation due to inadequate ventilation. Three orotracheal intubation patients had a bronchospasm or laryngospasm during awakening. Forty-five patients (24.1%) had complex aneurysms or a history of subarachnoid hemorrhage. Thirty-three of them (73.3%) required orotracheal intubation compared to 24 of the 142 (16.9%) with non-complex aneurysms. Two patients in each group died during early postoperative recovery. Two in each group also had intraoperative bleeding. A post-hoc analysis showed that orotracheal intubation was used in 55 patients (44%) in 2010 through 2014 and 2 (3.2%) in 2015 through 2018, parallel to a trend toward less invasive blood pressure monitoring from the earlier to the later period from 34 (27.2%) cases to 5 (8.2%).

* Corresponding author.
  *E-mail:* rvalero@clinic.cat (R. Valero).

*Conclusion:* Supraglottic device, like other less invasiveness protocols, can be considered a feasible alternative airway management approach in selected patients proposed for endovascular treatment of unruptured intracranial aneurisms.

## Introduction

The efficacy of endovascular intracranial aneurysm treatment has been recognized since the 1970s, and although its safety has been demonstrated in Unruptured Intracranial Aneurysms (UIAs), little has been published about perioperative anesthetic care in this setting.[1–3] The standard of care calls for general anesthesia with Orotracheal Intubation (OTI), muscle paralysis, controlled ventilation, and standard monitoring plus invasive arterial pressure recording to provide absolute immobility and strict hemodynamic control.[2]

However, OTI is associated with hemodynamic effects that may increase the risk of aneurysm rupture prior to occlusion. Furthermore, OTI is also associated with more coughing episodes and potentially deleterious hemodynamic changes during emergence compared to Supraglottic Devices (SGD), which have less impact in the sympathetic nervous system.[4–6] Nevertheless, there is concern that SGD may not provide the same degree of airway protection and safety as OTI during these long procedures.[3]

Only a few case series, including a limited number of patients, have reported the feasibility of SGD during endovascular treatment of UIAs.[7,8] We present the analysis of our 9-year experience with using SGD as an alternative to assess the feasibility of this approach to airway management in patients undergoing endovascular treatment in UIAs.

## Materials and methods

This retrospective cohort study was approved by the research ethics committee at our university hospital (reference HCB/2018/0691) and registered at clinicaltrials.org (NCT03632902). The committee waived the requirement for specific written informed consent for use of data; thus, consent was obtained only for anesthesia and radiology procedures.

We reviewed the records of all patients who underwent endovascular treatment of a UIA from January 2010 to March 2018. Ruptured intracranial aneurysms were excluded.

### Anesthetic procedures and monitoring

Our institutional protocol included premedication with 5 mg of oral diazepam the night before and 2 hours before surgery, continuation of corticosteroids or anticonvulsants throughout the procedure and antibiotic prophylaxis (intravenous [IV] ceftriaxone, 2 g).

Continuous monitoring consisted of blood pressure (arterial cannulation or use of a noninvasive monitor [ccNexfin,

BMEYE, Irvine, CA, USA]), electrocardiogram, and the Bispectral Index monitoring (BIS, Brain Monitoring System; Covidien, Mansfield, MA, USA), pulse oximetry (S/5; Datex Ohmeda, Helsinki, Finland); and bilateral regional Oxygen Saturation ($SrO_2$) (INVOS 5100C Cerebral/Somatic Oximeter, Minneapolis, MN, USA). Each patient was preoxygenated (100% oxygen) through a face mask. All procedures were performed under general anesthesia. Intravenous anesthesia was administered through a target-controlled infusion system (Orchestra Infusion Workstation, Primea Base; Fresenius Vial, Bad Homburg v.d.H., Germany) with propofol (target concentration, 4–6 $\mu$g.mL$^{-1}$) and remifentanil (target, 2–4 $\eta$g.mL$^{-1}$) adjusted to keep the bispectral index close to 50. Rocuronium bolus 1 mg.Kg$^{-1}$ followed by continuous perfusion (0.1 mg.Kg$^{-1}$.h$^{-1}$) was administered to maintain one response of a train-of-four (S/5 Datex Ohmeda®, Helsinki, Finlandia). The anesthesiologist, who was experienced in airway management, was free to choose either SGD (I-gel, Intersurgical Ltd, Wokingham, Berkshire, UK) or OTI airway management, according to their own clinical criteria, always following current airway management guidelines.

A bolus dose of heparin (100 IU.kg$^{-1}$ IV) was administered at the start of the procedure. The level of anticoagulation was monitored with the activated clotting time (ACT, GEM PCL plus, Bedford, MA, USA), and doses of heparin were repeated if necessary.

In the absence of complications, a dose of 2 mg.Kg$^{-1}$ sugammadex was administered, patients were to be awakened and extubated (or the SGD removed) immediately after the end of the procedure for early neurological examination and then transferred to the stroke unit or the postanesthetic care unit.

### Data collection

The main goal was to analyze the type of airway management technique used (SGD or OTI) and airway related events and complications: laryngospasm, bronchospasm, arterial oxygen desaturation (< 95% measured by pulse oximetry), gastric content aspiration and airway symptoms within the first month (during hospitalization or outpatient follow-up). We also collected whether a difficult airway had been anticipated during the preanesthetic assessment. For SGD-managed airways, we recorded the need to reposition it to optimize ventilation or to switch to OTI because of failed SGD insertion. Details of airway management strategies were also extracted for intubated patients.

The analysis included demographic data, aneurysm characteristics, history of arterial hypertension, type of anesthesia, and method of arterial blood pressure monitor-

**Table 1** Patient and aneurysm characteristics.

|  | OTI | SGD | Total | p |
|---|---|---|---|---|
| Nº of patients | 57 | 130 | 187 | |
| Sex,          F | 40 (89.5) | 100 (76.9) | 140 (74.9) | 0.31 |
| n (%)          M | 17 (10.5) | 30 (23.1) | 47 (25.1) | |
| Age, mean (SD), y | 61 (10.5) | 57.8 (11.0) | 58.8 (10.9) | 0.07 |
| BMI, mean (SD), kg·m$^{-2}$ | 25.6 (5.25) | 24.5 (4.2) | 24.7 (4.5) | 0.24 |
| Anticipated difficult airway, n (%) | 6 (10.5) | 7 (5.4) | 13 (6.8) | 0.19 |
| Hypertension, n (%)[a] | 26/57 | 50/130 | 77 (41.2) | 0.36 |
| Aneurysm location, n (%) | | | | 0.65 |
| Anterior circulation | 45 (79) | 99 (76.2) | 144 (77) | |
| Posterior circulation | 12 (21) | 31 (23.8) | 43 (23) | |
| Complexity, n (%)[b] | 33 (57.9) | 12 (9.2) | 45 (24.1) | 0.001 |

Quantitative and qualitative variables were compared with the *t* test or $\chi^2$ test, respectively.

BMI, Body Mass Index; OTI, Orotracheal Tube; SGD, Supraglottic Device.

[a] Past medical history of hypertension in medical treatment.

[b] Previous history of subarachnoid haemorrhage or aneurism complexity score $\geq 4$ on a scale of 0 to 7.

ing. To assess the procedure potential risks, previous history of subarachnoid hemorrhage and aneurysm complexity were also recorded. Complexity was defined by a score of 4 or more points on a scale of 0 to 7 derived by giving one point to each of the following characteristics: wide neck, significant lobulation, calcifications, intra-aneurysmal thrombosis, tortuosity or stenosis of proximal vessels, small size (less than 3 mm), and presence of branches in the sack.

## Statistical analysis

Quantitative variables were expressed as mean (SD) and qualitative variables as absolute frequency and percentage. Statistics were compared between groups with the *t*-test or $\chi^2$ test, as appropriate. In a post-hoc analysis we also explored variables that might be associated with differing airway management decisions in two consecutive time periods: 2010 to 2014 and 2015 to 2018.

IBM SPSS Statistics 23 for Windows (IBM Corp, Armonk NY, USA) was used for all analyses. A value of *p* < 0.05 was considered statistically significant.

## Results

A total of 187 patients were treated during the study period, 130 (69.5%) of them received a SGD group and 57 (30.5%) were managed with OTI. There were no differences in demographic characteristics, history of hypertension, or anticipated difficult airway rates between the two airway management groups (Table 1).

All incidents during airway management are described in Table 2. In the 3 SGD patients whose device required repositioning, adequate ventilation was achieved on the second attempt. No episodes of desaturation or gastric content aspiration developed in SGD patients. The single laryngospasm in the OTI group occurred during awakening and was associated with intense coughing. The 2 fiberoptic bronchoscope insertions in the OTI group were performed in patients with predicted difficult intubation.

Three postoperative pneumonias (1 in the SGD group and 2 in the OTI group) were diagnosed. All 3 pneumonias were in patients that remained intubated when transferred to the intensive care unit.

OTI was the preferred technique for patients with increased risk of complications either due to previous history of subarachnoid hemorrhage or to the presence of a complex aneurysm. Tracheal intubation was performed in 33 of the 47 high-risk patients (73.3%), but only in 24 of the 142 patients (16.9%) without these risk factors (*p* < 0.0001) (Table 1).

Four patients, 2 in each group, died while in the postoperative period (2.1% of the cohort of 187 patients). Three of the deaths (2 of them in the OTI group) had complex aneurysms. Two OTI patients bled during the procedure and remained intubated when transferred to the intensive care unit, where they died. Postoperative bleeding was detected in 2 SGD patients. The first presented with mild right paresis that progressed to diminished consciousness over the next few hours. This patient was immediately intubated, a pericallosal artery bleed was observed with cranial tomography, and transferred to the ICU. The second developed a headache and experienced vasospasm after being asymptomatic for the first 6 hours after awakening. Subarachnoid bleeding was diagnosed by cranial tomography and the patient was admitted in the ICU. Eleven days later, a bilateral cerebral stroke involving the middle cerebral and anterior cerebral arteries was observed and he died a few days later.

There was a parallel trend toward the use of less invasive airway management and less invasive blood pressure monitoring over the period of study. A post-hoc analysis showed that OTI was used in 55 patients (44%) from 2010 to 2014 and 2 (3.2%) from 2015 to 2018, parallel to a trend toward less invasive blood pressure monitoring from the earlier to the later period; from 34 (27.2%) cases to 5 (8.2%).

## Discussion

In our case series, the use of SGD provided effective airway management during endovascular treatment of UIAs

**Table 2** Events during airway management by group and anticipated difficult airway classification.

| | No ADA | ADA | Total |
|---|---|---|---|
| **SGD group** | | | |
| No incidences, n (%) | 119 (91.5%) | 7 (5.4%) | 126 (96.9%) |
| **Incidents, n (%)** | | | |
| Repositioning[a] | 3 (2.3%) | 0 | 3 (2.3%) |
| Switch to OTI | 1 (0.8%) | 0 | 1 (0.8%) |
| Total, n (%) | 124 (95.4%) | 7 (5.4%) | 130 |
| **OTI group** | | | |
| No incidences, n (%) | 49 (86%) | 3 (5.3%) | 52 (91.2%) |
| Incidents, n (%) | 2 (3.5%) | 1 (1.7%) | 3 (5.3%) |
| Laryngospasm | 0 | 1 (1.7%) | |
| Broncospasm | 2 (3.5%) | 0 | |
| Fiberoptic intubation, n (%) | 0 | 2 (3.5%) | 2 (3.5%) |
| Total, n (%) | 51 (89.5%) | 6 (10.5%) | 57 |

ADA, Anticipated Difficult Airway; SGD, Supraglottic Device; NA, Not Applicable; OTI, Orotracheal Intubation.

  [a] SGD repositioning or adjustment manoeuvres were needed to improve ventilation.

and was associated with a low incidence of airway-related events or complications. No major airway complications occurred in the patients whose airways were managed with SGD. Post-procedure pneumonia was diagnosed in 3 patients under prolonged mechanical ventilation due to neurological complications that cannot be attributed to airway instrumentation during the procedure. To date, no randomized trials or prospective studies comparing OTI to SGD management in neuroradiological interventions have been published; only data from two retrospective observational studies in this setting are available, including 3 and 26 cases of uneventful SGD use,[7,8] which is consistent with our findings.

During endovascular embolization of intracranial aneurysm, the transmural pressure gradient of the aneurysm sac must remain constant[2,9,10] to decrease the risk of rupture, estimated to be 1.4% of the cases.[11] Furthermore, preventing the ischemia and bleeding that can occur at different moments, during or shortly after the procedure, requires a strict and continuous control of the hemodynamic and respiratory parameters, in particular during the induction of anesthesia and the awakening period. As studies in other settings have demonstrated the benefit of using SGD to reduce the deleterious hemodynamic impact of airway manipulation during induction and emergence of anesthesia in comparison to OTI, it could be speculated that they may contribute to reduce the risk of aneurysm rupture and postoperative intracranial bleeding.[6,12,13] The data of our retrospective analysis do not allow drawing conclusions because more patients with high risk for complication were managed with OTI. In our series, 4 cases of aneurysm rupture and bleeding occurred. The 2 patients in the OTI group were still intubated. The 2 patients in the SGD group were intubated postoperatively and transferred to the intensive care unit when neurological status declined after several hours. Although complications after uneventful endovascular procedures seem to be rare,[14] it appears very important to monitor these patients very closely and evaluate neurological function often during the first 6 hours of recovery to detect events early, as we did in our series. An additional advantages of SGD use is that

the early and smooth recovery from anesthesia, facilitating the immediate assessment of neurological status after the procedure, which has been found to be beneficial.[15]

The shift toward SGD in our series progressed alongside a transition to minimally invasive periprocedural protocols, including the use of noninvasive continuous monitoring, as better equipment became available. This evolution in clinical practice also reflects the consolidation of our collective experience in the use SGD in neuroanesthesia.[6,16,17]

However, controversy still exist over the use SGD for endovascular treatment of UIAs, as for other neurosurgical procedures, based on concerns over their efficacy and safety on protecting the airway. In our 9-year experience, no complication related to the use of SGD, such as severe hypoxemia or aspiration of gastric contents, were detected and all airway related events were easily solved by repositioning or adjusting the device. These encouraging results could be explained by a prudent patient selection considering several factors. First, patients estimated to be at risk for carotid rupture or cervical bleeding and those with decreased level of consciousness were managed with OTI. Second, patients with predicted difficult airways were managed according to institutional protocols, performing awake tracheal intubation if indicated by the preanesthetic airway evaluation findings. Notwithstanding, 7-patients with criteria for difficult intubation, but not for difficult ventilation or SGD placement, were managed uneventfully with such devices. Third, the number of patients managed with SGD increased steadily as the members of the neuroanesthesia team gained expertise in their use, to include the vast majority of patients scheduled for embolization of unruptured aneurysms. Fourth, an SGD that is appropriate for the indication should be used, and a second-generation device is recommended for advanced uses. Only second-generation SGD were used in our case series, the I-gel was the most commonly available in the radiological suite as it does not have metal components.

Our retrospective analysis has several limitations. First, the number of patients and the severity of their risk factors for complications were not evenly distributed between the groups of patients. Second, data related to hemody-

namic and respiratory changes, particularly during induction and emergence from anesthesia, was not precise enough to draw conclusions about the benefits of SGD use over the OTI. Finally, our single center study, with a limited sample size, is not large enough to support the safety of SGD use during the endovascular treatment of UIAs.

In conclusion, our experience suggests that the use of SGD I-gel is a feasible airway management approach for patients proposed for endovascular treatment of UIAs under minimally invasive periprocedural management protocols.

## Conflicts of interest

The authors declare no conflicts of interest.

## Acknowledgements

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