

# World Journal of *Clinical Cases*

*World J Clin Cases* 2022 September 26; 10(27): 9550-9969



**OPINION REVIEW**

- 9550 Psychiatric disorders and pain: The recurrence of a comorbidity  
*Vyshka G*

**REVIEW**

- 9556 Cardiovascular disease and COVID-19, a deadly combination: A review about direct and indirect impact of a pandemic  
*Vidal-Perez R, Brandão M, Pazdernik M, Kresoja KP, Carpenito M, Maeda S, Casado-Arroyo R, Muscoli S, Pöss J, Fontes-Carvalho R, Vazquez-Rodriguez JM*
- 9573 Molecular factors, diagnosis and management of gastrointestinal tract neuroendocrine tumors: An update  
*Pavlidis ET, Pavlidis TE*

**MINIREVIEWS**

- 9588 Human-induced pluripotent stem cell-atrial-specific cardiomyocytes and atrial fibrillation  
*Leowattana W, Leowattana T, Leowattana P*
- 9602 COVID-19 and the cardiovascular system-current knowledge and future perspectives  
*Chatzis DG, Magounaki K, Pantazopoulos I, Bhaskar SMM*

**ORIGINAL ARTICLE****Case Control Study**

- 9611 PDCA nursing in improving quality management efficacy in endoscopic submucosal dissection  
*He YH, Wang F*

**Retrospective Study**

- 9619 Impact of COVID-19 pandemic on the ocular surface  
*Marta A, Marques JH, Almeida D, José D, Sousa P, Barbosa I*
- 9628 Anatomy and clinical application of suprascapular nerve to accessory nerve transfer  
*Wang JW, Zhang WB, Li F, Fang X, Yi ZQ, Xu XL, Peng X, Zhang WG*
- 9641 Therapeutic effect of two methods on avulsion fracture of tibial insertion of anterior cruciate ligament  
*Niu HM, Wang QC, Sun RZ*
- 9650 Efficacy of transcatheter arterial chemoembolization using pirarubicin-loaded microspheres combined with lobaplatin for primary liver cancer  
*Zhang C, Dai YH, Lian SF, Liu L, Zhao T, Wen JY*

- 9657** Prognostic significance of sex determining region Y-box 2, E-cadherin, and vimentin in esophageal squamous cell carcinoma

*Li C, Ma YQ*

- 9670** Clinical characteristics and prognosis of orbital solitary fibrous tumor in patients from a Chinese tertiary eye hospital

*Ren MY, Li J, Wu YX, Li RM, Zhang C, Liu LM, Wang JJ, Gao Y*

### Observational Study

- 9680** Altered heart rate variability and pulse-wave velocity after spinal cord injury

*Tsou HK, Shih KC, Lin YC, Li YM, Chen HY*

- 9693** Intra and extra pelvic multidisciplinary surgical approach of retroperitoneal sarcoma: Case series report

*Song H, Ahn JH, Jung Y, Woo JY, Cha J, Chung YG, Lee KH*

### META-ANALYSIS

- 9703** Meta-analysis of gemcitabine plus nab-paclitaxel combined with targeted agents in the treatment of metastatic pancreatic cancer

*Li ZH, Ma YJ, Jia ZH, Weng YY, Zhang P, Zhu SJ, Wang F*

- 9714** Clinical efficacy analysis of mesenchymal stem cell therapy in patients with COVID-19: A systematic review

*Cao JX, You J, Wu LH, Luo K, Wang ZX*

### CASE REPORT

- 9727** Treatment of gastric cancer with dermatomyositis as the initial symptom: Two case reports and review of literature

*Sun XF, Gao XD, Shen KT*

- 9734** Gallbladder hemorrhage—An uncommon surgical emergency: A case report

*Valenti MR, Cavallaro A, Di Vita M, Zanghi A, Longo Trischitta G, Cappellani A*

- 9743** Successful treatment of stage IIIB intrahepatic cholangiocarcinoma using neoadjuvant therapy with the PD-1 inhibitor camrelizumab: A case report

*Zhu SG, Li HB, Dai TX, Li H, Wang GY*

- 9750** Myocarditis as an extraintestinal manifestation of ulcerative colitis: A case report and review of the literature

*Wang YY, Shi W, Wang J, Li Y, Tian Z, Jiao Y*

- 9760** Endovascular treatment of traumatic renal artery pseudoaneurysm with a Stanford type A intramural haematoma: A case report

*Kim Y, Lee JY, Lee JS, Ye JB, Kim SH, Sul YH, Yoon SY, Choi JH, Choi H*

- 9768** Histiocytoid giant cellulitis-like Sweet syndrome at the site of sternal aspiration: A case report and review of literature

*Zhao DW, Ni J, Sun XL*

- 9776** Rare giant corneal keloid presenting 26 years after trauma: A case report  
*Li S, Lei J, Wang YH, Xu XL, Yang K, Jie Y*
- 9783** Efficacy evaluation of True Lift®, a nonsurgical facial ligament retightening injection technique: Two case reports  
*Huang P, Li CW, Yan YQ*
- 9790** Synchronous primary duodenal papillary adenocarcinoma and gallbladder carcinoma: A case report and review of literature  
*Chen J, Zhu MY, Huang YH, Zhou ZC, Shen YY, Zhou Q, Fei MJ, Kong FC*
- 9798** Solitary fibrous tumor of the renal pelvis: A case report  
*Liu M, Zheng C, Wang J, Wang JX, He L*
- 9805** Gastric metastasis presenting as submucosa tumors from renal cell carcinoma: A case report  
*Chen WG, Shan GD, Zhu HT, Chen LH, Xu GQ*
- 9814** Laparoscopic correction of hydronephrosis caused by left paraduodenal hernia in a child with cryptorchism: A case report  
*Wang X, Wu Y, Guan Y*
- 9821** Diagnosed corrected transposition of great arteries after cesarean section: A case report  
*Ichii N, Kakinuma T, Fujikawa A, Takeda M, Ohta T, Kagimoto M, Kaneko A, Izumi R, Kakinuma K, Saito K, Maeyama A, Yanagida K, Takeshima N, Ohwada M*
- 9828** Misdiagnosis of an elevated lesion in the esophagus: A case report  
*Ma XB, Ma HY, Jia XF, Wen FF, Liu CX*
- 9834** Diagnostic features and therapeutic strategies for malignant paraganglioma in a patient: A case report  
*Gan L, Shen XD, Ren Y, Cui HX, Zhuang ZX*
- 9845** Infant with reverse-transcription polymerase chain reaction confirmed COVID-19 and normal chest computed tomography: A case report  
*Ji GH, Li B, Wu ZC, Wang W, Xiong H*
- 9851** Pulmonary hypertension secondary to seronegative rheumatoid arthritis overlapping antisynthetase syndrome: A case report  
*Huang CY, Lu MJ, Tian JH, Liu DS, Wu CY*
- 9859** Monitored anesthesia care for craniotomy in a patient with Eisenmenger syndrome: A case report  
*Ri HS, Jeon Y*
- 9865** Emergency treatment and anesthesia management of internal carotid artery injury during neurosurgery: Four case reports  
*Wang J, Peng YM*

- 9873** Resolution of herpes zoster-induced small bowel pseudo-obstruction by epidural nerve block: A case report  
*Lin YC, Cui XG, Wu LZ, Zhou DQ, Zhou Q*
- 9879** Accidental venous port placement *via* the persistent left superior vena cava: Two case reports  
*Zhou RN, Ma XB, Wang L, Kang HF*
- 9886** Application of digital positioning guide plates for the surgical extraction of multiple impacted supernumerary teeth: A case report and review of literature  
*Wang Z, Zhao SY, He WS, Yu F, Shi SJ, Xia XL, Luo XX, Xiao YH*
- 9897** Iatrogenic aortic dissection during right transradial intervention in a patient with aberrant right subclavian artery: A case report  
*Ha K, Jang AY, Shin YH, Lee J, Seo J, Lee SI, Kang WC, Suh SY*
- 9904** Pneumomediastinum and subcutaneous emphysema secondary to dental extraction: Two case reports  
*Ye LY, Wang LF, Gao JX*
- 9911** Hemorrhagic shock due to submucosal esophageal hematoma along with mallory-weiss syndrome: A case report  
*Oba J, Usuda D, Tsuge S, Sakurai R, Kawai K, Matsubara S, Tanaka R, Suzuki M, Takano H, Shimozawa S, Hotchi Y, Usami K, Tokunaga S, Osugi I, Katou R, Ito S, Mishima K, Kondo A, Mizuno K, Takami H, Komatsu T, Nomura T, Sugita M*
- 9921** Concurrent severe hepatotoxicity and agranulocytosis induced by *Polygonum multiflorum*: A case report  
*Shao YL, Ma CM, Wu JM, Guo FC, Zhang SC*
- 9929** Transient ischemic attack after mRNA-based COVID-19 vaccination during pregnancy: A case report  
*Chang CH, Kao SP, Ding DC*
- 9936** Drug-induced lung injury caused by acetaminophen in a Japanese woman: A case report  
*Fujii M, Kenzaka T*
- 9945** Familial mitochondrial encephalomyopathy, lactic acidosis, and stroke-like episode syndrome: Three case reports  
*Yang X, Fu LJ*
- 9954** Renal pseudoaneurysm after rigid ureteroscopic lithotripsy: A case report  
*Li YH, Lin YS, Hsu CY, Ou YC, Tung MC*

**LETTER TO THE EDITOR**

- 9961** Role of traditional Chinese medicine in the initiative practice for health  
*Li Y, Li SY, Zhong Y*
- 9964** Impact of the COVID-19 pandemic on healthcare workers' families  
*Helou M, El Osta N, Husni R*

- 9967** Transition beyond the acute phase of the COVID-19 pandemic: Need to address the long-term health impacts of COVID-19

*Tsioutis C, Tofarides A, Spernovasilis N*

**ABOUT COVER**

Editorial Board Member of *World Journal of Clinical Cases*, Yusuf Tutar, PhD, Chairman, Director, Full Professor, Department of Basic Pharmaceutical Sciences, Division of Biochemistry, University of Health Sciences, Istanbul 34668, Turkey. ytutar@outlook.com

**AIMS AND SCOPE**

The primary aim of *World Journal of Clinical Cases* (*WJCC*, *World J Clin Cases*) is to provide scholars and readers from various fields of clinical medicine with a platform to publish high-quality clinical research articles and communicate their research findings online.

*WJCC* mainly publishes articles reporting research results and findings obtained in the field of clinical medicine and covering a wide range of topics, including case control studies, retrospective cohort studies, retrospective studies, clinical trials studies, observational studies, prospective studies, randomized controlled trials, randomized clinical trials, systematic reviews, meta-analysis, and case reports.

**INDEXING/ABSTRACTING**

The *WJCC* is now abstracted and indexed in Science Citation Index Expanded (SCIE, also known as SciSearch®), Journal Citation Reports/Science Edition, Current Contents®/Clinical Medicine, PubMed, PubMed Central, Scopus, Reference Citation Analysis, China National Knowledge Infrastructure, China Science and Technology Journal Database, and Superstar Journals Database. The 2022 Edition of Journal Citation Reports® cites the 2021 impact factor (IF) for *WJCC* as 1.534; IF without journal self cites: 1.491; 5-year IF: 1.599; Journal Citation Indicator: 0.28; Ranking: 135 among 172 journals in medicine, general and internal; and Quartile category: Q4. The *WJCC*'s CiteScore for 2021 is 1.2 and Scopus CiteScore rank 2021: General Medicine is 443/826.

**RESPONSIBLE EDITORS FOR THIS ISSUE**

Production Editor: *Ying-Yi Yuan*; Production Department Director: *Xiang Li*; Editorial Office Director: *Jin-Lei Wang*.

**NAME OF JOURNAL**

*World Journal of Clinical Cases*

**ISSN**

ISSN 2307-8960 (online)

**LAUNCH DATE**

April 16, 2013

**FREQUENCY**

Thrice Monthly

**EDITORS-IN-CHIEF**

Bao-Gan Peng, Jerzy Tadeusz Chudek, George Kontogeorgos, Maurizio Serati, Ja Hyeon Ku

**EDITORIAL BOARD MEMBERS**

<https://www.wjgnet.com/2307-8960/editorialboard.htm>

**PUBLICATION DATE**

September 26, 2022

**COPYRIGHT**

© 2022 Baishideng Publishing Group Inc

**INSTRUCTIONS TO AUTHORS**

<https://www.wjgnet.com/bpg/gerinfo/204>

**GUIDELINES FOR ETHICS DOCUMENTS**

<https://www.wjgnet.com/bpg/GerInfo/287>

**GUIDELINES FOR NON-NATIVE SPEAKERS OF ENGLISH**

<https://www.wjgnet.com/bpg/gerinfo/240>

**PUBLICATION ETHICS**

<https://www.wjgnet.com/bpg/GerInfo/288>

**PUBLICATION MISCONDUCT**

<https://www.wjgnet.com/bpg/gerinfo/208>

**ARTICLE PROCESSING CHARGE**

<https://www.wjgnet.com/bpg/gerinfo/242>

**STEPS FOR SUBMITTING MANUSCRIPTS**

<https://www.wjgnet.com/bpg/GerInfo/239>

**ONLINE SUBMISSION**

<https://www.f6publishing.com>

## Emergency treatment and anesthesia management of internal carotid artery injury during neurosurgery: Four case reports

Jie Wang, Yu-Ming Peng

**Specialty type:** Medicine, research and experimental

**Provenance and peer review:** Unsolicited article; Externally peer reviewed.

**Peer-review model:** Single blind

**Peer-review report's scientific quality classification**

Grade A (Excellent): 0  
Grade B (Very good): B  
Grade C (Good): C  
Grade D (Fair): 0  
Grade E (Poor): E

**P-Reviewer:** Al-Ani RM, Iraq; Oley MH, Indonesia

**Received:** May 11, 2022

**Peer-review started:** May 11, 2022

**First decision:** May 31, 2022

**Revised:** June 19, 2022

**Accepted:** August 17, 2022

**Article in press:** August 17, 2022

**Published online:** September 26, 2022



**Jie Wang, Yu-Ming Peng**, Department of Anesthesiology, Beijing Tiantan Hospital, Capital Medical University, Beijing 100070, China

**Corresponding author:** Yu-Ming Peng, MD, PhD, Chief Doctor, Department of Anesthesiology, Beijing Tiantan Hospital, Capital Medical University, No. 119 Southwest 4<sup>th</sup> Ring Road, Beijing 100070, China. [florapym766@163.com](mailto:florapym766@163.com)

### Abstract

#### BACKGROUND

During skull base surgery, intraoperative internal carotid artery (ICA) injury is a catastrophic complication that can lead to fatal blood loss or secondary cerebral ischemia. Appropriate management of ICA injury plays a crucial role in the prognosis of patients. Neurosurgeons have reported multiple techniques and management strategies; however, the literature on managing this complication from the anesthesiologist's perspective is limited, especially in the aspect of circulation management and airway management when patients need transit for further endovascular treatment.

#### CASE SUMMARY

We describe 4 cases of ICA injury during neurosurgery; there were 3 cases of pathologically proven pituitary adenoma and 1 case of cavernous sinus endothelial meningioma. After the onset of ICA injury, all four patients were immediately transferred for endovascular therapy under general anesthesia with vital signs monitored and mechanical ventilation. Three patients were transferred to the hybrid operating room, and one patient was transferred to the catheter operating room. Three patients underwent covered stent implantation, and one patient underwent embolization. All four patients experienced hypovolemic shock and received blood products infusion and vasoactive drugs to maintain stable circulation. After the neurosurgery, one patient was extubated and returned to the ward, and the other three were delayed tracheal extubation and returned to the intensive care unit. One patient died from serious neurological complications after 62 d in the hospital, but the other three showed good clinical outcomes.

#### CONCLUSION

ICA injury imposes a high risk of massive hemorrhage and subsequent infarction. Immediate treatment is critical and requires interdisciplinary collaboration among neurosurgeons, anesthesiologists, and interventional neuroradiologists. Effective hemostatic methods, stable hemodynamics sufficient to ensure perfusion of vital

organs, airway safety during transit, rapid localization and implementation of appropriate measures to occlude the damaged vessel are strong guarantees of patient safety.

**Key Words:** Complication; Internal carotid artery injury; Neurosurgery; Anesthesia Management; Literature review; Case reports

©The Author(s) 2022. Published by Baishideng Publishing Group Inc. All rights reserved.

**Core Tip:** Intraoperative internal carotid artery (ICA) injury is an uncommon but life-threatening event that usually requires transfer to a hybrid or catheter operating room for urgent endovascular treatment; however, the literature on the management of this complication from the anesthesiologist's perspective is limited. This case series documents four cases of ICA injury during skull base neurosurgery. Effective hemostatic procedures, hemodynamic stabilization and maintenance of mechanical ventilation during and after transfer, rapid localization and implementation of necessary measures to occlude the injured vessel are solid guarantees of patient safety.

**Citation:** Wang J, Peng YM. Emergency treatment and anesthesia management of internal carotid artery injury during neurosurgery: Four case reports. *World J Clin Cases* 2022; 10(27): 9865-9872

**URL:** <https://www.wjgnet.com/2307-8960/full/v10/i27/9865.htm>

**DOI:** <https://dx.doi.org/10.12998/wjcc.v10.i27.9865>

## INTRODUCTION

Internal carotid artery (ICA) injury is a rare but catastrophic complication. As anterior, medial, and lateral skull base tumors often close to the ICA, there is an inherent risk of injuring the ICA[1]. Due to publication bias, the reported incidence of ICA injury varies widely. The incidence of ICA injury in traditional craniotomy for the resection of skull base masses is approximately 3%-8% [2] and varies from 0.4%-9% in endoscopic neurosurgery[3-5]. Nasal packing, muscle patches, direct vessel closure, and endovascular techniques have been described as useful strategies for managing ICA bleeds[6]. In this paper, we described the anesthetic management of 4 cases of ICA injury during neurosurgery at Tiantan Hospital, especially in the aspect of circulation management and airway management when patients need transit for further endovascular treatment.

## CASE PRESENTATION

### Chief complaints

**Case 1:** A 51-year-old female presented with paroxysmal headache for 7 mo (Table 1).

**Case 2:** A 57-year-old female presented with an intermittent headache for over a month.

**Case 3:** A 32-year-old male presented with facial changes for three months.

**Case 4:** A 53-year-old female presented with intermittent headache and dizziness for 1 year and exacerbation for 3 mo.

### History of present illness

**Case 1:** The patient underwent pituitary adenoma surgery 7 years prior and denied any other symptoms.

**Case 2:** There were no other symptoms.

**Case 3:** There were no other symptoms.

**Case 4:** There were no other symptoms.

### History of past illness

**Case 1:** The patient had no other medical history.

**Case 2:** The patient had a history of hyperthyroidism that had been cured.

Table 1 The demographic and clinical characteristics of the 4 patients

Case	Age (yr)	Sex	BMI (kg/m <sup>2</sup> )	Primary disease	Comorbidities	Maximum diameter of tumor (mm)	Tumor recurrence (yes/no)	Operative approach	Location of ICA injury
1	51	Female	25.28	Pituitary adenoma	None	20	Yes	ETTS	C5 segment of right internal carotid artery
2	57	Female	21.50	Pituitary adenoma	Hyperthyroidism, cured	46	No	ETTS	C4 segment of left internal carotid artery
3	32	Male	26.12	Pituitary adenoma	None	30	No	MTTS	C5 segment of right internal carotid artery
4	53	Female	25.63	Right cavernous sinus endothelial meningioma	Allergic asthma	35	No	Right fronto-temporal approach	C5 segment of right internal carotid artery

BMI: Body mass index; ETTS: Endoscopic transnasal transsphenoidal approach; MTTS: Microscopically transnasal transsphenoidal approach.

**Case 3:** The patient had no other medical history.

**Case 4:** The patient had a history of allergic asthma.

#### **Personal and family history**

**Case 1:** The patient had no history of smoking or drinking, and no family history.

**Case 2:** The patient had no history of smoking or drinking, and no family history.

**Case 3:** The patient had a history of smoking. The patient's parents are alive and healthy.

**Case 4:** The patient had no history of smoking or drinking. The patient's father had died of a stroke. The patient's mother is alive and healthy.

#### **Physical examination**

**Case 1:** The visual acuity of both eyes decreased, and the left upper visual field partially defected; the rest nervous system examination was negative.

**Case 2:** The nervous system examination was negative.

**Case 3:** Physical examination revealed hypertrophy of the lips and acromegaly; the rest nervous system examination was negative.

**Case 4:** The nervous system examination was negative.

#### **Laboratory examinations**

**Case 1:** The growth hormone was mildly elevated at 8.3 ng/mL (reference range: 0-8.0 ng/mL).

**Case 2:** The patient's blood test results were all normal.

**Case 3:** The patient exhibited multiple pituitary hormone abnormal (growth hormone level, > 40.0 ng/mL, reference range: 0-8.0 ng/mL; prolactin level, 143 ng/mL, reference range: 1.9-25 ng/mL).

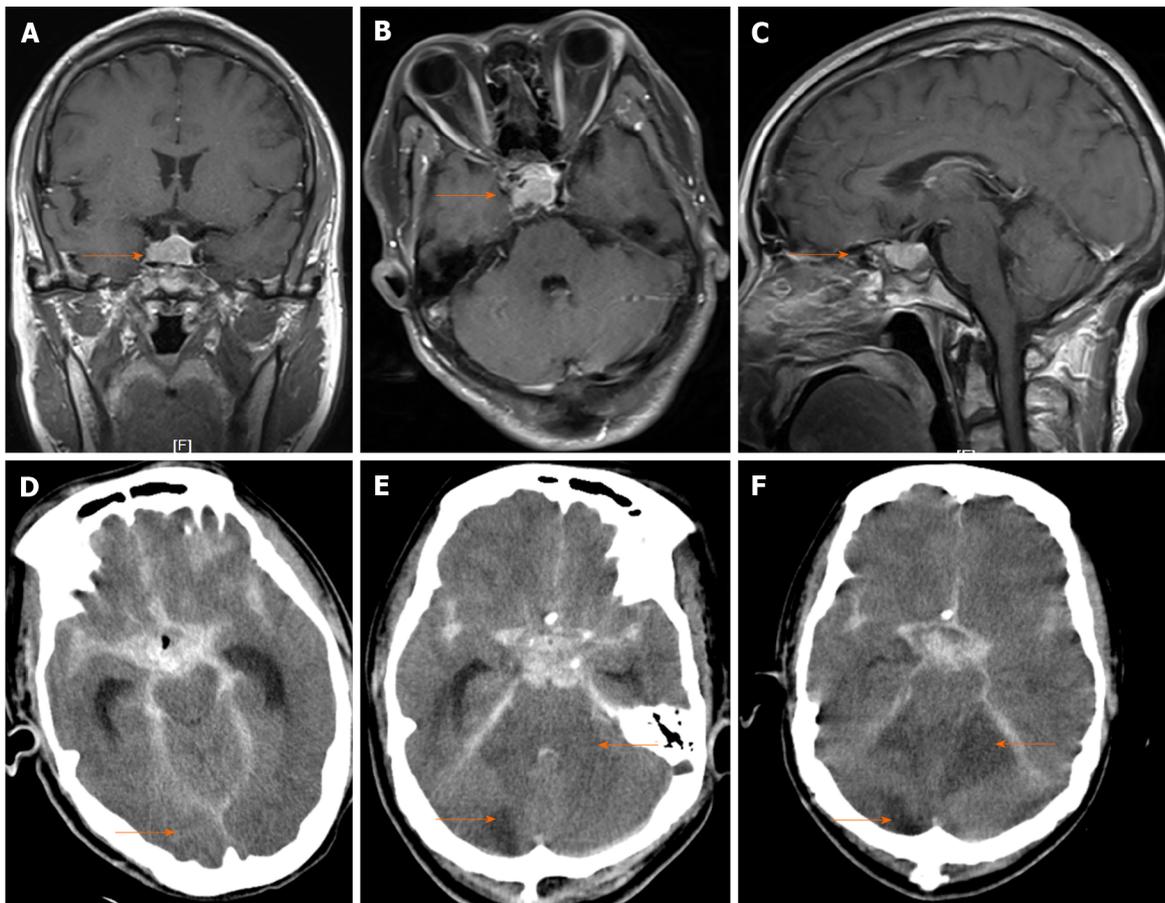
**Case 4:** The patient's blood test results were all normal.

#### **Imaging examinations**

Magnetic resonance imaging (Figures 1A-C) performed before surgery showed that the ICA was enveloped by a sellar tumor. Time-varying computed tomography (CT) (Figures 1D-F) performed after surgery showed intracerebral hemorrhage and progressive cerebral infarction (orange arrow).

### **FINAL DIAGNOSIS**

**Case 1:** The patient was diagnosed with pituitary adenoma.



DOI: 10.12998/wjcc.v10.i27.9865 Copyright ©The Author(s) 2022.

**Figure 1** Preoperative magnetic resonance imaging and postoperative computed tomography images in case 1 (orange arrow). A-C: Magnetic resonance imaging showed occupation in the sellar region; D-F: Computed tomography showed intracerebral hemorrhage on the day of surgery and progressive cerebral infarction on postoperative days 2 and 4, respectively.

**Case 2:** The patient was diagnosed with pituitary adenoma.

**Case 3:** The patient was diagnosed with pituitary adenoma.

**Case 4:** The patient was diagnosed with right cavernous sinus endothelial meningioma.

## TREATMENT

**Case 1:** Endoscopic transsphenoidal pituitary adenoma surgery was performed under general anesthesia. After curettage of most of the tumor, a large amount of bloody fluid gushed out from the sellar region, at which time sponges were immediately placed to temporarily stop the bleeding. The patient was immediately transferred to a hybrid operating room with controlled ventilation. During the transfer, vital signs were monitored, and the depth of anesthesia was maintained with a combination of propofol and remifentanyl infusions. Injury of the right ICA was confirmed by digital subtraction angiography, and the injury was sealed with a covered stent. The overall volume of blood loss was 2400 mL. Fluid resuscitation, vasoactive drugs (epinephrine), and blood products were used to maintain circulation during the operation. After surgery, the patient was returned to the intensive care unit (ICU) under tracheal intubation and mechanical ventilation (Table 2).

**Case 2:** Endoscopic transnasal resection of the sphenoidal tumor was performed under general anesthesia. When the operation was continued to remove the tumor in the left cavernous sinus, severe bleeding occurred. After compression with a hemostatic sponge, the patient was immediately transferred to a catheter operating room with controlled ventilation. During the transfer, vital signs were monitored, and the depth of anesthesia was maintained with a combination of propofol and remifentanyl infusions. The C4 segment of the left ICA was confirmed to be injured and was treated with a covered stent. The total volume of blood loss was 3000 mL. Fluid resuscitation, vasoactive drugs (dopamine), and blood products were used to maintain circulation during the operation. After surgery,

**Table 2 Anesthesia management for subsequent surgery and the clinical outcome of the 4 patients**

Case	ASA class	Type of anesthesia	Vasoactive drugs	Total infusion (mL)	RBC (mL)	FFP (mL)	Blood loss (mL)	Urine output (mL)	Tumor removal	Endovascular treatment	Prolonged intubation (d)	Length of stay (d)	Outcome	Hospital costs (RMB)
1	IV	TIVA	Adrenaline	6000	520	800	2400	750	Near total	Covered stent	55	62	Died	402167.49
2	III	TIVA	Dopamine	6000	1560	1200	3000	3500	Near total	Covered stent	0	12	Recovered	221113.41
3	III	CIIA	Norepinephrine and adrenaline	4000	260	400	900	800	Near total	Covered stent	1	17	Recovered	209218.11
4	III	CIIA	Norepinephrine and adrenaline	6600	1000	400	2200	4100	Total	Right ICA embolism	1	22	Recovered	165178.78

ASA: American Society of Anesthesiologists; TIVA: Total intravenous anesthesia; CIIA: Combined intravenous and inhaled anesthesia; RBC: Red blood cells; FFP: Fresh frozen plasma; ICA: Internal carotid artery.

the patient was extubated and returned to the ward.

**Case 3:** Transsphenoidal microsurgery was performed under general anesthesia. When the bone window was enlarged, the ICA was penetrated by bone debris. Immediately after the injury, the area of hemorrhage was packed, and the patient was transferred to the hybrid operating room. The C5 segment of the right ICA was confirmed to be injured and was treated with a covered stent. During the transfer, vital signs were monitored, and the depth of anesthesia was maintained with a combination of midazolam and rocuronium. The total volume of blood loss was 1000 mL. Fluid resuscitation, vasoactive drugs (norepinephrine and epinephrine), and blood products were used to maintain circulation during the operation. After surgery, the patient was returned to the ICU under tracheal intubation and spontaneous breathing.

**Case 4:** Craniotomy with the right frontotemporal approach was performed under general anesthesia. The tumor tightly encircled the right ICA and invaded the arterial wall. During the separation of the residual tumor, injury to the ICA occurred. The area of hemorrhage was immediately packed, and the patient was transferred to the hybrid operating room. The C5 segment of the right ICA was confirmed to be injured and was treated with coil embolization. During the transfer, vital signs were monitored, and the depth of anesthesia was maintained with a combination of propofol and remifentanyl infusions. The total volume of blood loss was 2200 mL. Fluid resuscitation, vasoactive drugs (norepinephrine and epinephrine), and blood products were used to maintain circulation during the operation. After surgery, the patient was returned to the ICU under tracheal intubation with spontaneous breathing.

## OUTCOME AND FOLLOW-UP

**Case 1:** The patient remained in a coma with a Glasgow Coma Scale score of 3 without spontaneous breathing until postoperative day 11. Subsequently, brainstem failure, multiple cerebral infarcts,

respiratory and circulatory failure, severe electrolyte disturbances, and deep venous thrombosis occurred gradually. The time-varying CT images are shown in [Figure 1](#). The patient died 62 d after the surgery ([Table 2](#)).

**Case 2:** The patient did not develop any neurological sequelae and was discharged after 12 d of hospitalization.

**Case 3:** The patient did not develop any neurological sequelae and was discharged after 17 d of hospitalization.

**Case 4:** The patient experienced transient left upper extremity weakness and was discharged after 22 d of hospitalization.

---

## DISCUSSION

---

Although ICA injury is rare during skull base neurosurgery, it receives considerable attention due to its potentially catastrophic consequences, which include massive hemorrhage and even circulation collapse and secondary ischemia. The reported incidence of ICA injury varies from 0.34%-2.6% with transsphenoidal surgery, 3%-8% with standard open skull base approaches, and 0.16%-2% with endoscopic skull base surgery[7-10]. These differences in incidence result from differences in the surgical techniques, complexity of access, and tumor size. In addition, the rate of variation in the course and geometry of the ICA can be as high as 40%, which further increases the risk of potential injury[11]. In this paper, 3 of the 4 patients were treated with the transsphenoidal approach, and 1 of them underwent craniotomy.

Due to different approaches and angles of craniotomy, intraoperative ICA injury is more likely to occur in the cavernous segment during endoscopic approaches and in the postcavernous segment during anterior and middle skull base surgery. The petrous segment is at risk during both open and endoscopic lateral skull base surgery[1]. As Gardner *et al*[12] mentioned, primary prevention is the best management strategy. Individual preoperative risk evaluation is mandatory if intraoperative manipulation of the ICA is anticipated[13]. A comprehensive preoperative evaluation includes an assessment of the tumor size, the relationship between the tumor and the ICA (encapsulation, invasion, or displacement of the ICA), and the patient's risk tolerance. It should be noted that previous surgery, previous radiotherapy, sphenoid wall defects, encapsulation of the ICA by the tumor, and more ectatic arteries due to acromegaly are risk factors for ICA injury[1,7,14,15]. Regarding the preparation for anesthesia, placing two peripheral lines for rapid perfusion and keeping two units of blood products in the operating room for patients with a high risk of ICA injury are necessary[16]. In addition to routine monitoring, it has been recommended to place an arterial catheter in the dorsal pedis artery or radial artery after anesthesia induction.

In the event of intraoperative ICA injury, neurosurgeons, anesthesiologists, and interventional neuroradiologists should collaborate as a team to manage this emergency situation. Successful primary repair of an injured ICA by encasing the injured vessel with a synthetic or autologous material, patching or wrapping with muscle grafts, or other methods of hemostasis is of the utmost importance. In this paper, all 4 patients who experienced ICA injury during skull base neurosurgery under general anesthesia were immediately transferred to a hybrid or catheter operating room for endovascular treatment after effective hemostasis. Patient safety must be ensured during the transfer process. Multivital sign monitoring, controlled breathing and stable blood pressure to maintain target organ perfusion during transport are critical to patient safety. Previous studies recommended that blood pressures should be kept normal to high to ensure adequate cerebral perfusion during the management of an ICA injury[12,16,17].

Since the patients have been endotracheally intubated, it is relatively easy to manage the airway and control breathing to maintain oxygenation during transfer, and if conditions permit, transport ventilators can be used, which may be safer. Continuous intravenous infusion of propofol and remifentanyl in combination with a muscle relaxant (rocuronium or cisatracurium) could be used to maintain a certain depth of anesthesia to prevent coughing and any body movement during transfer to avoid exacerbation of the ICA injury and deterioration of the current situation. However, patients with ICA injury usually experience hypovolemic shock. Our primary goal was to prevent circulation collapse. Patients with massive bleeding and profound hemodynamic instability could be treated with resuscitation measures, including limited transfusion of crystalloids, whole blood, or balanced blood components and vasoactive agents as needed. In this paper, 3 of 4 patients lost more than 2000 mL of blood. All patients received an infusion of blood products and vasoactive drugs, such as dopamine, epinephrine, and norepinephrine, or a combination of both to maintain hemodynamic stability.

Subsequent arteriography was performed under general anesthesia. Both intravenous and volatile agents can be used to maintain anesthesia, although short-acting agents are preferred. The tracheal tube was successfully removed in 1 patient, and removal was delayed in 3 patients. One patient died of brainstem failure, multiple cerebral infarcts, and respiratory and circulatory failure ([Figure 1](#)) despite

active postoperative hemostasis, vascular preservation, and intracranial pressure reduction. One patient experienced transient neurological impairment but had recovered by the time of discharge, whereas the other 2 patients exhibited no neurological sequelae.

---

## CONCLUSION

Anesthesia management of ICA injury during skull base surgery requires optimal surgical conditions while maintaining hemodynamic stability to ensure vital organ perfusion and airway safety during and after transfer. Preoperative risk assessment and intraoperative multidisciplinary collaboration are the cornerstones of perioperative safety.

---

## FOOTNOTES

**Author contributions:** Wang J contributed to data collection and reviewed the literature and manuscript drafts; Peng YM contributed to manuscript editing; and all authors have read and approved the final manuscript.

**Informed consent statement:** Informed written consent was obtained from the patient for publication of this report and any accompanying images.

**Conflict-of-interest statement:** All the authors report no relevant conflicts of interest for this article.

**CARE Checklist (2016) statement:** The authors have read the CARE Checklist (2016), and the manuscript was prepared and revised according to the CARE Checklist (2016).

**Open-Access:** This article is an open-access article that was selected by an in-house editor and fully peer-reviewed by external reviewers. It is distributed in accordance with the Creative Commons Attribution NonCommercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited and the use is non-commercial. See: <https://creativecommons.org/licenses/by-nc/4.0/>

**Country/Territory of origin:** China

**ORCID number:** Jie Wang 0000-0002-4438-1082; Yu-Ming Peng 0000-0002-2630-2467.

**S-Editor:** Wang JJ

**L-Editor:** A

**P-Editor:** Wang JJ

---

## REFERENCES

- 1 **Van Der Veken J**, Simons M, Mulcahy MJ, Wurster C, Harding M, Van Velthoven V. The surgical management of intraoperative intracranial internal carotid artery injury in open skull base surgery-a systematic review. *Neurosurg Rev* 2022; **45**: 1263-1273 [PMID: 34802074 DOI: 10.1007/s10143-021-01692-1]
- 2 **Inamasu J**, Guiot BH. Iatrogenic carotid artery injury in neurosurgery. *Neurosurg Rev* 2005; **28**: 239-47; discussion 248 [PMID: 16091974 DOI: 10.1007/s10143-005-0412-7]
- 3 **Hosemann W**, Schroeder HW. Comprehensive review on rhino-neurosurgery. *GMS Curr Top Otorhinolaryngol Head Neck Surg* 2015; **14**: Doc01 [PMID: 26770276 DOI: 10.3205/cto000116]
- 4 **AlQahtani A**, London NR Jr, Castelnovo P, Locatelli D, Stamm A, Cohen-Gadol AA, Elbosraty H, Casiano R, Morcos J, Pasquini E, Frank G, Mazzatenta D, Barkhoudarian G, Griffiths C, Kelly D, Georgalas C, Janakiram N, Nicolai P, Prevedello DM, Carrau RL. Assessment of Factors Associated With Internal Carotid Injury in Expanded Endoscopic Endonasal Skull Base Surgery. *JAMA Otolaryngol Head Neck Surg* 2020; **146**: 364-372 [PMID: 32105301 DOI: 10.1001/jamaoto.2019.4864]
- 5 **Valentine R**, Padhye V, Wormald PJ. Management of arterial injury during endoscopic sinus and skull base surgery. *Curr Opin Otolaryngol Head Neck Surg* 2016; **24**: 170-174 [PMID: 26959844 DOI: 10.1097/MOO.0000000000000239]
- 6 **Hamour AF**, Laliberte F, Padhye V, Monteiro E, Agid R, Lee JM, Witterick IJ, Vescan AD. Development of a management protocol for internal carotid artery injury during endoscopic surgery: a modified Delphi method and single-center multidisciplinary working group. *J Otolaryngol Head Neck Surg* 2022; **51**: 30 [PMID: 35902904 DOI: 10.1186/s40463-022-00582-w]
- 7 **Sylvester PT**, Moran CJ, Derdeyn CP, Cross DT, Dacey RG, Zipfel GJ, Kim AH, Uppaluri R, Haughey BH, Tempelhoff R, Rich KM, Schneider J, Chole RA, Chicoine MR. Endovascular management of internal carotid artery injuries secondary to endonasal surgery: case series and review of the literature. *J Neurosurg* 2016; **125**: 1256-1276 [PMID: 26771847 DOI: 10.3171/2015.6.JNS142483]
- 8 **Valentine R**, Wormald PJ. Carotid artery injury after endonasal surgery. *Otolaryngol Clin North Am* 2011; **44**: 1059-1079

- [PMID: 21978896 DOI: 10.1016/j.otc.2011.06.009]
- 9 **Bafaquh M**, Khairy S, Alyamany M, Alobaid A, Alzhrani G, Alkhaibary A, Aldhafeeri WF, Alaman AA, Aljohani HN, Elahi BN, Alhabban FA, Orz Y, Alturki AY. Classification of internal carotid artery injuries during endoscopic endonasal approaches to the skull base. *Surg Neurol Int* 2020; **11**: 357 [PMID: 33194290 DOI: 10.25259/SNI\_188\_2020]
  - 10 **Chin OY**, Ghosh R, Fang CH, Baredes S, Liu JK, Eloy JA. Internal carotid artery injury in endoscopic endonasal surgery: A systematic review. *Laryngoscope* 2016; **126**: 582-590 [PMID: 26525334 DOI: 10.1002/lary.25748]
  - 11 **Gardner PA**, Tormenti MJ, Pant H, Fernandez-Miranda JC, Snyderman CH, Horowitz MB. Carotid artery injury during endoscopic endonasal skull base surgery: incidence and outcomes. *Neurosurgery* 2013; **73**: ons261-9; discussion ons269 [PMID: 23695646 DOI: 10.1227/01.neu.0000430821.71267.f2]
  - 12 **Gardner PA**, Snyderman CH, Fernandez-Miranda JC, Jankowitz BT. Management of Major Vascular Injury During Endoscopic Endonasal Skull Base Surgery. *Otolaryngol Clin North Am* 2016; **49**: 819-828 [PMID: 27267028 DOI: 10.1016/j.otc.2016.03.003]
  - 13 **Xiao L**, Xie S, Tang B, Wu X, Ding H, Bao Y, Hong T. A novel technique to manage internal carotid artery injury in endoscopic endonasal skull base surgery in the premise of proximal and distal controls. *Neurosurg Rev* 2021; **44**: 3437-3445 [PMID: 33738637 DOI: 10.1007/s10143-021-01517-1]
  - 14 **Morrison T**, Jukes A, Wong J. Rupture from cavernous internal carotid artery pseudoaneurysm 11 years after transsphenoidal surgery. *J Clin Neurosci* 2020; **79**: 266-268 [PMID: 33070909 DOI: 10.1016/j.jocn.2020.06.018]
  - 15 **Zada G**, Cavallo LM, Esposito F, Fernandez-Jimenez JC, Tasiou A, De Angelis M, Cafiero T, Cappabianca P, Laws ER. Transsphenoidal surgery in patients with acromegaly: operative strategies for overcoming technically challenging anatomical variations. *Neurosurg Focus* 2010; **29**: E8 [PMID: 20887133 DOI: 10.3171/2010.8.FOCUS10156]
  - 16 **Kassir ZM**, Gardner PA, Wang EW, Zenonos GA, Snyderman CH. Identifying Best Practices for Managing Internal Carotid Artery Injury During Endoscopic Endonasal Surgery by Consensus of Expert Opinion. *Am J Rhinol Allergy* 2021; **35**: 885-894 [PMID: 34236268 DOI: 10.1177/194589242111024864]
  - 17 **AlQahtani A**, Castelnovo P, Nicolai P, Prevedello DM, Locatelli D, Carrau RL. Injury of the Internal Carotid Artery During Endoscopic Skull Base Surgery: Prevention and Management Protocol. *Otolaryngol Clin North Am* 2016; **49**: 237-252 [PMID: 26614841 DOI: 10.1016/j.otc.2015.09.009]



Published by **Baishideng Publishing Group Inc**  
7041 Koll Center Parkway, Suite 160, Pleasanton, CA 94566, USA  
**Telephone:** +1-925-3991568  
**E-mail:** [bpgoffice@wjgnet.com](mailto:bpgoffice@wjgnet.com)  
**Help Desk:** <https://www.f6publishing.com/helpdesk>  
<https://www.wjgnet.com>

