Internal carotid artery injury after transsphenoidal approach

Internal carotid artery injury is a potentially lethal complication in transsphenoidal approach for pituitary lesions. The intercarotid distance (ICD) is thus a major parameter, determining the width of the surgical corridor.

Unrelated pathology may complicate a transsphenoidal approach: rare, e.g. a parasellar aneurysm.

Carotid artery rupture: rare. May occur intraoperatively or in a delayed fashion after surgery, often ≈ day 10 post-op (due to the breakdown of fibrin around carotid, or possibly due to rupture of a pseudoaneurysm created at surgery).

If a pseudoaneurysm or site of injury is identified angiographically, it must be eliminated before a potentially lethal hemorrhage; accomplished either by endovascular techniques or by surgical trapping with clips above and below.

Case reports

Haley et al. reported a case of coil migration into the oropharynx five years after treatment of a left internal carotid pseudoaneurysm following abandoned transsphenoidal resection of a pituitary macroadenoma. Eight other cases were found on literature review, with coil migration occurring between 2 and 120 months often after a history of transsphenoidal surgery. The majority of these were treated with trimming in a day case setting. This report highlights the need for careful extended follow up when a pseudoaneurysm forms with a concurrent skull base deficit [1)].

Unclassified

1: Cossu G, Al-Taha K, Hajdu SD, Daniel RT, Messerer M. Carotid-Cavernous Fistula After Transsphenoidal Surgery: A Rare but Challenging Complication. World Neurosurg. 2019 Nov 8;134:221-227. doi: 10.1016/j.wneu.2019.10.194. [Epub ahead of print] Review. PubMed PMID: 31712112.

2: Tyagi G, Sadashiva N, Konar S, Aravinda HR, Saini J, Shukla D, Devi BI. Persistent Trigeminal Artery: Neuroanatomic and Clinical Relevance. World Neurosurg. 2019 Oct 15. pii: S1878-8750(19)32640-3. doi: 10.1016/j.wneu.2019.10.025. [Epub ahead of print] PubMed PMID: 31627002.

3: Newman H, Milne N, Lewis SB. Neurosurgical Anatomy of the Internal Carotid Artery: Magnetic Resonance Imaging Study of the Sellar Region. World Neurosurg. 2020 Jan;133:e711-e715. doi: 10.1016/j.wneu.2019.09.145. Epub 2019 Oct 4. PubMed PMID: 31589983.

4: Nariai Y, Kawamura Y, Takigawa T, Hyodo A, Suzuki K. Pipeline embolization for an iatrogenic intracranial internal carotid artery pseudoaneurysm after transsphenoidal pituitary tumor surgery:

Case report and review of the literature. Interv Neuroradiol. 2019 Sep 10:1591019919874943. doi: 10.1177/1591019919874943. [Epub ahead of print] PubMed PMID: 31505983.

5: Perry A, Graffeo CS, Meyer J, Carlstrom LP, Oushy S, Driscoll CLW, Meyer FB. Beyond the Learning Curve: Comparison of Microscopic and Endoscopic Incidences of Internal Carotid Injury in a Series of Highly Experienced Operators. World Neurosurg. 2019 Nov;131:e128-e135. doi: 10.1016/j.wneu.2019.07.074. Epub 2019 Jul 15. PubMed PMID: 31319187.

6: Donoho DA, Johnson CE, Hur KT, Buchanan IA, Fredrickson VL, Minneti M, Zada G, Wrobel BB. Costs and training results of an objectively validated cadaveric perfusion-based internal carotid artery injury simulation during endoscopic skull base surgery. Int Forum Allergy Rhinol. 2019 Jul;9(7):787-794. doi: 10.1002/alr.22319. Epub 2019 Mar 18. PubMed PMID: 30884191.

7: Wang C, Zhang Y, Wang J, Ni S. Anterior Cerebral Artery Rupture During Extended Endoscopic Endonasal Transsphenoidal Approach for Severely Calcified Craniopharyngioma. World Neurosurg. 2019 Jun;126:537-540. doi: 10.1016/j.wneu.2019.02.128. Epub 2019 Mar 4. PubMed PMID: 30844531.

8: Güler TM, Yılmazlar S, Özgün G. Anatomical aspects of optic nerve decompression in transcranial and transsphenoidal approach. J Craniomaxillofac Surg. 2019 Apr;47(4):561-569. doi: 10.1016/j.jcms.2019.01.027. Epub 2019 Feb 13. PubMed PMID: 30837103.

9: Grandhi R, Brasiliense LBC, Williamson R, Zwagerman NT, Sauvageau E, Hanel RA. Delayed Pipeline Embolization of a Ruptured True Internal Carotid Artery Aneurysm Presenting with Epistaxis: Case Report and Review of the Literature. World Neurosurg. 2019 May;125:273-276. doi: 10.1016/j.wneu.2019.01.126. Epub 2019 Feb 1. Review. PubMed PMID: 30716493.

10: Giorgianni A, Pozzi F, Pellegrino C, Padovan S, Karligkiotis A, Castelnuovo P, Locatelli D. Emergency placement of a Flow diverter for an Iatrogenic Internal Carotid Artery Injury During Endoscopic Pituitary Surgery. World Neurosurg. 2019 Feb;122:376-379. doi: 10.1016/j.wneu.2018.10.234. Epub 2018 Nov 12. PubMed PMID: 30439523.

11: Yeung W, Twigg V, Carr S, Sinha S, Mirza S. Radiological “Teddy Bear” Sign on CT Imaging to Aid Internal Carotid Artery Localization in Transsphenoidal Pituitary and Anterior Skull Base Surgery. J Neurol Surg B Skull Base. 2018 Aug;79(4):401-406. doi: 10.1055/s-0037-1615749. Epub 2017 Dec 26. PubMed PMID: 30009122; PubMed Central PMCID: PMC6043166.

12: van Doormaal TPC, Diederen SJH, van der Zwan A, Berkelbach JW, Kropveld A, Depauw PRAM. Simulating Internal Carotid Artery Injury during Transsphenoidal Transclival Endoscopic Surgery in a Perfused Cadaver Model. J Neurol Surg B Skull Base. 2018 Apr;79(2):161-166. doi: 10.1055/s-0037-1605594. Epub 2017 Aug 23. PubMed PMID: 29868321; PubMed Central PMCID: PMC5978857.

13: Sami MT, Gattozzi DA, Soliman HM, Reeves AR, Moran CJ, Camarata PJ, Ebersole KC. Use of Pipeline™ embolization device for the treatment of traumatic intracranial pseudoaneurysms: Case series and review of cases from literature. Clin Neurol Neurosurg. 2018 Jun;169:154-160. doi: 10.1016/j.clineuro.2018.04.012. Epub 2018 Apr 14. Review. PubMed PMID: 29698879.

14: Dal Secchi MM, Dolci RLL, Teixeira R, Lazarini PR. An Analysis of Anatomic Variations of the Sphenoid Sinus and Its Relationship to the Internal Carotid Artery. Int Arch Otorhinolaryngol. 2018 Apr;22(2):161-166. doi: 10.1055/s-0037-1607336. Epub 2017 Oct 25. PubMed PMID: 29619106; PubMed Central PMCID: PMC5882364.

15: Khachatryan T, Khachatryan M, Fanarjyan R, Grigoryan M, Grigorian A. Enlargement of an incidental internal carotid artery aneurysm embedded in pituitary neuroendocrine tumor associated with medical shrinkage of the tumor: Case report. Surg Neurol Int. 2018 Feb 14;9:30. doi: 10.4103/sni.sni_317_17. eCollection 2018. PubMed PMID: 29527388; PubMed Central PMCID: PMC5838828.

16: Romero ADCB, Lal Gangadharan J, Bander ED, Gobin YP, Anand VK, Schwartz TH. Managing Arterial Injury in Endoscopic Skull Base Surgery: Case Series and Review of the Literature. Oper Neurosurg (Hagerstown). 2017 Feb 1;13(1):138-149. doi: 10.1227/NEU.0000000000001180. Review. PubMed PMID: 28931251.

17: Wang S, Qin Y, Xiao D, Wei L. Efficacy of sellar opening in the pituitary adenoma resection of transsphenoidal surgery influences the degree of tumor resection. BMC Med Imaging. 2017 Jul 24;17(1):45. doi: 10.1186/s12880-017-0217-5. PubMed PMID: 28738798; PubMed Central PMCID: PMC5525237.

18: Manjila S, Singh G, Ndubuizu O, Jones Z, Hsu DP, Cohen AR. Endovascular plug for internal carotid artery occlusion in the management of a cavernous pseudoaneurysm with bifrontal subdural empyema: technical note. J Neurosurg Pediatr. 2017 Sep;20(3):239-246. doi: 10.3171/2017.3.PEDS16370. Epub 2017 Jun 16. PubMed PMID: 28621574.

19: Jukes A, Murphy J, Vreugde S, Psaltis A, Wormald PJ. Nano-hemostats and a Pilot Study of Their Use in a Large Animal Model of Major Vessel Hemorrhage in Endoscopic Skull Base Surgery. J Neurol Surg B Skull Base. 2017 Jun;78(3):215-221. doi: 10.1055/s-0036-1597277. Epub 2016 Dec 12. PubMed PMID: 28593108; PubMed Central PMCID: PMC5461165.

20: Kalinin P, Sharipov O, Kutin M, Fomichev D, Gavrjushin A, Polev G, Shults Y, Avdeeva K. Amygdalohippocampectomy via the Lateral Extended Transsphenoidal Endoscopic Approach Through the Pterygopalatine Fossa: An Anatomic Study. World Neurosurg. 2017 Jul;103:457-464. doi: 10.1016/j.wneu.2017.04.052. Epub 2017 Apr 19. PubMed PMID: 28434957.

21: Almefty R, Dunn IF, Aziz-Sultan MA, Al-Mefty O. Delayed Carotid Pseudoaneurysms from Iatrogenic Clival Meningeal Branches Avulsion: Recognition and Proposed Management. World Neurosurg. 2017 Aug;104:736-744. doi: 10.1016/j.wneu.2017.03.016. Epub 2017 Mar 12. PubMed PMID: 28300709.

22: 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 Nov;125(5):1256-1276. Epub 2016 Jan 15. Review. PubMed PMID: 26771847.

23: Lin BJ, Chung TT, Lin MC, Lin C, Hueng DY, Chen YH, Hsia CC, Ju DT, Ma HI, Liu MY, Tang CT. Quantitative analysis of anatomical relationship between cavernous segment internal carotid artery and pituitary macroadenoma. Medicine (Baltimore). 2016 Oct;95(41):e5027. PubMed PMID: 27741111; PubMed Central PMCID: PMC5072938.

24: Aydin E, Gok M, Esenkaya A, Cinar C, Oran I. Endovascular Management of Iatrogenic Vascular Injury in the Craniocervical Region. Turk Neurosurg. 2018;28(1):72-78. doi: 10.5137/1019-5149.JTN.18189-16.1. PubMed PMID: 27593845.

25: Tang CL, Liao CH, Chen WH, Shen SC, Lee CH, Lee HT, Tsuei YS. Endoscope-assisted transsphenoidal puncture of the cavernous sinus for embolization of carotid-cavernous fistula in a neurosurgical hybrid operating suite. J Neurosurg. 2017 Aug;127(2):327-331. doi: 10.3171/2016.5.JNS16493. Epub 2016 Aug 5. PubMed PMID: 27494822.

26: Muto J, Carrau RL, Oyama K, Otto BA, Prevedello DM. Training model for control of an internal carotid artery injury during transsphenoidal surgery. Laryngoscope. 2017 Jan;127(1):38-43. doi: 10.1002/lary.26181. Epub 2016 Jul 28. PubMed PMID: 27470428.

27: Dolati P, Eichberg D, Golby A, Zamani A, Laws E. Multimodal Navigation in Endoscopic Transsphenoidal Resection of Pituitary Tumors Using Image-Based Vascular and Cranial Nerve Segmentation: A Prospective Validation Study. World Neurosurg. 2016 Nov;95:406-413. doi: 10.1016/j.wneu.2016.06.008. Epub 2016 Jun 11. PubMed PMID: 27302558; PubMed Central PMCID: PMC5143211.

28: Hayashi Y, Kita D, Iwato M, Fukui I, Sasagawa Y, Oishi M, Tachibana O, Nakada M. Midline dural filum of the sellar floor: Its relationship to the septum attachment to the sellar floor and the ossification in the sphenoid sinus. Clin Neurol Neurosurg. 2016 Aug;147:53-8. doi: 10.1016/j.clineuro.2016.05.007. Epub 2016 May 19. PubMed PMID: 27290638.

29: Ramalho CO, Marenco HA, de Assis Vaz Guimarães Filho F, da Costa MD, de Oliveira Santos BF, de Paula Santos R, Zymberg ST. Intrasphenoid septations inserted into the internal carotid arteries: a frequent and risky relationship in transsphenoidal surgeries. Braz J Otorhinolaryngol. 2017 Mar - Apr;83(2):162-167. doi: 10.1016/j.bjorl.2016.02.007. Epub 2016 Apr 22. PubMed PMID: 27174772.

30: Sharipov OI, Kutin MA, Kalinin PL, Fomichev DV, Lukshin VA, Kurnosov AB. [The use of intraoperative Doppler ultrasound in endoscopic transsphenoidal surgery]. Zh Vopr Neirokhir Im N N Burdenko. 2016;80(2):15-20. doi: 10.17116/neiro201680215-20. English, Russian. PubMed PMID: 27070254.

31: Usachev DY, Lukshin VA, Yakovlev SB, Kalinin PL, Sharipov OI, Kutin MA, Akhmedov AD, Bocharov AV, Aref'ev AM. [Combined surgical treatment of cavernous internal carotid artery pseudoaneurysm]. Zh Vopr Neirokhir Im N N Burdenko. 2016;80(5):116-123. doi: 10.17116/neiro2016805116-122. Russian. PubMed PMID: 28635696.

32: Tantongtip D, Fratianni A, Jenkner J, Arnold S, Spetzger U. Surgical Treatment of Inadvertent Internal Carotid Artery Lesion by Extraintracranial High-flow Bypass. A Case Report and Review of the Literature. J Neurol Surg Rep. 2015 Jul;76(1):e100-4. doi: 10.1055/s-0035-1551670. Epub 2015 May 15. PubMed PMID: 26251782; PubMed Central PMCID: PMC4520998.

33: Mascarella MA, Forghani R, Di Maio S, Sirhan D, Zeitouni A, Mohr G, Tewfik MA. Indicators of a Reduced Intercarotid Artery Distance in Patients Undergoing Endoscopic Transsphenoidal Surgery. J Neurol Surg B Skull Base. 2015 Jun;76(3):195-201. doi: 10.1055/s-0034-1396601. Epub 2015 Jan 5. PubMed PMID: 26225301; PubMed Central PMCID: PMC4433390.

34: Iancu D, Lum C, Ahmed ME, Glikstein R, Dos Santos MP, Lesiuk H, Labib M, Kassam AB. Flow diversion in the treatment of carotid injury and carotid-cavernous fistula after transsphenoidal surgery. Interv Neuroradiol. 2015 Jun;21(3):346-50. doi: 10.1177/1591019915582367. Epub 2015 May 26. PubMed PMID: 26015526; PubMed Central PMCID: PMC4757274.

35: Štoković N, Trkulja V, Dumić-Čule I, Čuković-Bagić I, Lauc T, Vukičević S, Grgurević L. Sphenoid sinus types, dimensions and relationship with surrounding structures. Ann Anat. 2016 Jan;203:69-76. doi: 10.1016/j.aanat.2015.02.013. Epub 2015 Mar 20. PubMed PMID: 25843780.

36: Patel AS, Horton TG, Kalapos P, Cockroft KM. Onyx-HD 500 Embolization of a Traumatic Internal Carotid Artery Pseudoaneurysm after Transsphenoidal Surgery. J Neuroimaging. 2015 Jul-

Aug;25(4):656-9. doi: 10.1111/jon.12221. Epub 2015 Feb 16. PubMed PMID: 25682851.

37: Smith TR, Hulou MM, Huang KT, Nery B, de Moura SM, Cote DJ, Laws ER. Complications after transsphenoidal surgery for patients with Cushing's disease and silent corticotroph adenomas. Neurosurg Focus. 2015 Feb;38(2):E12. doi: 10.3171/2014.10.FOCUS14705. PubMed PMID: 25639314.

38: Lubnin AY. [The article by Kalinin et al. “Injury to the cavernous segment of the internal artery upon transsphenoidal endoscopic removal of pituitary adenomas” (2013, N° 6)]. Zh Vopr Neirokhir Im N N Burdenko. 2014;78(5):64-5. English, Russian. PubMed PMID: 25516999.

39: Kim BM, Jeon P, Kim DJ, Kim DI, Suh SH, Park KY. Jostent covered stent placement for emergency reconstruction of a ruptured internal carotid artery during or after transsphenoidal surgery. J Neurosurg. 2015 May;122(5):1223-8. doi: 10.3171/2014.10.JNS14328. Epub 2014 Nov 21. PubMed PMID: 25415067.

40: Tomio R, Toda M, Sutiono AB, Horiguchi T, Aiso S, Yoshida K. Grüber's ligament as a useful landmark for the abducens nerve in the transnasal approach. J Neurosurg. 2015 Mar;122(3):499-503. doi: 10.3171/2014.10.JNS132437. Epub 2014 Nov 7. PubMed PMID: 25380109.

41: Pham M, Kale A, Marquez Y, Winer J, Lee B, Harris B, Minnetti M, Carey J, Giannotta S, Zada G. A Perfusion-based Human Cadaveric Model for Management of Carotid Artery Injury during Endoscopic Endonasal Skull Base Surgery. J Neurol Surg B Skull Base. 2014 Oct;75(5):309-13. doi: 10.1055/s-0034-1372470. Epub 2014 May 2. PubMed PMID: 25301092; PubMed Central PMCID: PMC4176542.

42: Rangel-Castilla L, McDougall CG, Spetzler RF, Nakaji P. Urgent cerebral revascularization bypass surgery for iatrogenic skull base internal carotid artery injury. Neurosurgery. 2014 Dec;10 Suppl 4:640-7; discussion 647-8. doi: 10.1227/NEU.0000000000000529. PubMed PMID: 25181433.

43: Mortimer AM, Klimczak K, Nelson RJ, Renowden SA. Endovascular Management of Cavernous Internal Carotid Artery Pseudoaneurysms Following Transsphenoidal Surgery: A Report of Two Cases and Review of the Literature. Clin Neuroradiol. 2015 Sep;25(3):295-300. doi: 10.1007/s00062-014-0332-4. Epub 2014 Aug 20. Review. PubMed PMID: 25139269.

44: Shakir HJ, Garson AD, Sorkin GC, Mokin M, Eller JL, Dumont TM, Popat SR, Leonardo J, Siddiqui AH. Combined use of covered stent and flow diversion to seal iatrogenic carotid injury with vessel preservation during transsphenoidal endoscopic resection of clival tumor. Surg Neurol Int. 2014 May 31;5:81. doi: 10.4103/2152-7806.133638. eCollection 2014. PubMed PMID: 25024881; PubMed Central PMCID: PMC4093738.

45: Wu H, Guo L, Qiu Y, Yuan X. Cavernous internal carotid artery aneurysm after radiotherapy presenting with external ophthalmoplegia. J Craniofac Surg. 2014 Jul;25(4):e380-2. doi: 10.1097/SCS.0000000000000930. PubMed PMID: 25006955.

46: Kalinin PL, Sharipov OI, Shkarubo AN, Fomichev DV, Kutin MA, Alekseev SN, Kadashev BA, Iakovlev SB, Dorokhov PS, Bukharin EIu, Kurnosov AB, Popugaev KA. [Damage to the cavernous segment of internal carotid artery in transsphenoidal endoscopic removal of pituitary neuroendocrine tumors (report of 4 cases)]. Zh Vopr Neirokhir Im N N Burdenko. 2013;77(6):28-37; discussion 38. English, Russian. PubMed PMID: 24558752.

47: Gupta R, Sharma A, Vaishya R, Tandon M. Ischemic complications after pituitary surgery: a report of two cases. J Neurol Surg A Cent Eur Neurosurg. 2013 Dec;74 Suppl 1:e119-23. doi: 10.1055/s-0032-1328955. Epub 2013 Sep 7. PubMed PMID: 24014099.

48: Cheng Y, Liu M, Zhang S, Tian Y, Song D, Li Y, Luo Q. Optic canal (OC) and internal carotid artery (ICA) in sellar region. Surg Radiol Anat. 2013 Nov;35(9):797-801. doi: 10.1007/s00276-013-1193-2. Epub 2013 Sep 5. PubMed PMID: 24005376.

49: Wang C, Xie J, Cui D, Cheng Y, Zhang S. A new classification of cavernous segment of the internal carotid artery. J Craniofac Surg. 2013 Jul;24(4):1418-22. doi: 10.1097/SCS.0b013e318292c970. PubMed PMID: 23851822.

50: Cherla DV, Tomovic S, Liu JK, Eloy JA. The central Onodi cell: A previously unreported anatomic variation. Allergy Rhinol (Providence). 2013 Spring;4(1):e49-51. doi: 10.2500/ar.2013.4.0047. PubMed PMID: 23772328; PubMed Central PMCID: PMC3679569.

51: Sasagawa Y, Tachibana O, Doai M, Akai T, Tonami H, Iizuka H. Internal carotid arterial shift after transsphenoidal surgery in pituitary neuroendocrine tumors with cavernous sinus invasion. Pituitary. 2013 Dec;16(4):465-70. doi: 10.1007/s11102-013-0492-2. PubMed PMID: 23720159.

52: Shukla D, Sharma R, Devi BI, Sampath S. Rostral basilar artery syndrome following transsphenoidal surgery–a report of four cases. Acta Neurochir (Wien). 2013 Sep;155(9):1633-6; discussion 1636. doi: 10.1007/s00701-013-1698-9. Epub 2013 Apr 16. PubMed PMID: 23584392.

53: Cheng Y, Zhang H, Su L, Tian Y, Zhang S, Zheng Y, Cui D, Li Y, Wang Y. Anatomical study of cavernous segment of the internal carotid artery and its relationship to the structures in sella region. J Craniofac Surg. 2013 Mar;24(2):622-5. doi: 10.1097/SCS.0b013e3182801f30. PubMed PMID: 23524760.

54: Shoman N, Donaldson AM, Ksiazek J, Pensak ML, Zimmer LA. First stage in predicative measure for transnasal transsphenoidal approach to petrous apex cholesterol granuloma. Laryngoscope. 2013 Mar;123(3):581-3. doi: 10.1002/lary.23754. Epub 2013 Feb 12. PubMed PMID: 23404633.

55: Aktas U, Yilmazlar S, Ugras N. Anatomical restrictions in the transsphenoidal, transclival approach to the upper clival region: a cadaveric, anatomic study. J Craniomaxillofac Surg. 2013 Sep;41(6):457-67. doi: 10.1016/j.jcms.2012.11.011. Epub 2012 Dec 17. PubMed PMID: 23257317.

56: Zhang Y, Tian Y, Song J, Li Y, Li W. Internal carotid artery in endoscopic endonasal transsphenoidal surgery. J Craniofac Surg. 2012 Nov;23(6):1866-9. doi: 10.1097/SCS.0b013e31826bf22a. PubMed PMID: 23172428.

57: Mori R, Joki T, Matsuwaki Y, Karagiozov K, Murayama Y, Abe T. Initial experience of real-time intraoperative C-arm computed-tomography-guided navigation surgery for pituitary tumors. World Neurosurg. 2013 Feb;79(2):319-26. doi: 10.1016/j.wneu.2012.10.011. Epub 2012 Oct 6. PubMed PMID: 23046916.

58: Fu M, Patel T, Baehring JM, Bulsara KR. Cavernous carotid pseudoaneurysm following transsphenoidal surgery. J Neuroimaging. 2013 Jul;23(3):319-25. doi: 10.1111/j.1552-6569.2011.00677.x. Epub 2012 Jan 13. Review. PubMed PMID: 22243969.

59: Ogawa Y, Tominaga T. Extended transsphenoidal approach for tuberculum sellae meningioma–what are the optimum and critical indications? Acta Neurochir (Wien). 2012 Apr;154(4):621-6. doi: 10.1007/s00701-011-1266-0. Epub 2012 Jan 10. PubMed PMID: 22231779.

60: Meng XH, Xu BN, Wei SB, Zhou T, Chen XL, Yu XG, Zhou DB, Tong HY, Zhang JS, Zhao Y, Hou YZ. [High-field intraoperative magnetic resonance imaging suite with neuronavigation system:

implementation and preliminary experience in the pituitary neuroendocrine tumor operation with transsphenoidal approach]. Zhonghua Wai Ke Za Zhi. 2011 Aug 1;49(8):703-6. Chinese. PubMed PMID: 22168933.

61: Shin JH, Kim SW, Hong YK, Jeun SS, Kang SG, Kim SW, Cho JH, Park YJ. The Onodi cell: an obstacle to sellar lesions with a transsphenoidal approach. Otolaryngol Head Neck Surg. 2011 Dec;145(6):1040-2. doi: 10.1177/0194599811418040. Epub 2011 Aug 4. PubMed PMID: 21817156.

62: Locatelli M, Caroli M, Pluderi M, Motta F, Gaini SM, Tschabitscher M, Scarone P. Endoscopic transsphenoidal optic nerve decompression: an anatomical study. Surg Radiol Anat. 2011 Apr;33(3):257-62. doi: 10.1007/s00276-010-0734-1. Epub 2010 Oct 15. PubMed PMID: 20949271.

63: 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 Oct;29(4):E8. doi: 10.3171/2010.8.FOCUS10156. PubMed PMID: 20887133.

64: Ujifuku K, Matsuo T, Takeshita T, Hayashi Y, Hayashi K, Kitagawa N, Hayashi T, Suyama K, Nagata I. Malignant transformation of craniopharyngioma associated with moyamoya syndrome. Neurol Med Chir (Tokyo). 2010;50(7):599-603. PubMed PMID: 20671391.

65: Ghatge SB, Modi DB. Treatment of ruptured ICA during transsphenoidal surgery. Two different endovascular strategies in two cases. Interv Neuroradiol. 2010 Mar;16(1):31-7. Epub 2010 Mar 25. PubMed PMID: 20377977; PubMed Central PMCID: PMC3277969.

66: Ebner FH, Kuerschner V, Dietz K, Bueltmann E, Naegele T, Honegger J. Reduced intercarotid artery distance in acromegaly: pathophysiologic considerations and implications for transsphenoidal surgery. Surg Neurol. 2009 Nov;72(5):456-60; discussion 460. doi: 10.1016/j.surneu.2009.07.006. PubMed PMID: 19963090.

67: Park YS, Jung JY, Ahn JY, Kim DJ, Kim SH. Emergency endovascular stent graft and coil placement for internal carotid artery injury during transsphenoidal surgery. Surg Neurol. 2009 Dec;72(6):741-6. doi: 10.1016/j.surneu.2009.05.003. Epub 2009 Jul 14. PubMed PMID: 19604552.

68: Zhou WG, Yang ZQ. Complications of transsphenoidal surgery for sellar region: intracranial vessel injury. Chin Med J (Engl). 2009 May 20;122(10):1154-6. PubMed PMID: 19493462.

69: Zhao B, Wei YK, Li GL, Li YN, Yao Y, Kang J, Ma WB, Yang Y, Wang RZ. Extended transsphenoidal approach for pituitary neuroendocrine tumors invading the anterior cranial base, cavernous sinus, and clivus: a single-center experience with 126 consecutive cases. J Neurosurg. 2010 Jan;112(1):108-17. doi: 10.3171/2009.3.JNS0929. PubMed PMID: 19408986.

70: Charalampaki P, Ayyad A, Kockro RA, Perneczky A. Surgical complications after endoscopic transsphenoidal pituitary surgery. J Clin Neurosci. 2009 Jun;16(6):786-9. doi: 10.1016/j.jocn.2008.09.002. Epub 2009 Mar 16. PubMed PMID: 19289287.

71: Crowley RW, Dumont AS, Jane JA Jr. Bilateral intracavernous carotid artery pseudoaneurysms as a result of sellar reconstruction during the transsphenoidal resection of a pituitary macroadenoma: case report. Minim Invasive Neurosurg. 2009 Feb;52(1):44-8. doi: 10.1055/s-0028-1104611. Epub 2009 Feb 26. PubMed PMID: 19247905.

72: Polezhaev AV, Cherebillo VIu, Savello AV, Svistov DV. [Therapeutic management for iatrogenic injury of great arteries during transnasal surgery of tumors of the hypophysis]. Vestn Khir Im I I Grek.

2008;167(6):71-6. Russian. PubMed PMID: 19241822.

73: Li J, Wang J, Jing X, Zhang W, Zhang X, Qiu Y. Transsphenoidal optic nerve decompression: an endoscopic anatomic study. J Craniofac Surg. 2008 Nov;19(6):1670-4. doi: 10.1097/SCS.0b013e31818b4316. PubMed PMID: 19098578.

74: Georgalas C, Kania R, Guichard JP, Sauvaget E, Tran Ba Huy P, Herman P. Endoscopic transsphenoidal surgery for cholesterol granulomas involving the petrous apex. Clin Otolaryngol. 2008 Feb;33(1):38-42. doi: 10.1111/j.1749-4486.2007.01589.x. PubMed PMID: 18302553.

75: Kitano M, Taneda M, Shimono T, Nakao Y. Extended transsphenoidal approach for surgical management of pituitary neuroendocrine tumors invading the cavernous sinus. J Neurosurg. 2008 Jan;108(1):26-36. doi: 10.3171/JNS/2008/108/01/0026. PubMed PMID: 18173307.

76: Dusick JR, Esposito F, Malkasian D, Kelly DF. Avoidance of carotid artery injuries in transsphenoidal surgery with the Doppler probe and micro-hook blades. Neurosurgery. 2007 Apr;60(4 Suppl 2):322-8; discussion 328-9. PubMed PMID: 17415170.

77: Hattori I, Iwasaki K, Horikawa F, Tanji M, Gomi M. [Treatment of a ruptured giant internal carotid artery pseudoaneurysm following transsphenoidal surgery: case report and literature review]. No Shinkei Geka. 2006 Nov;34(11):1141-6. Japanese. PubMed PMID: 17087269.

78: Kurschel S, Leber KA, Scarpatetti M, Roll P. Rare fatal vascular complication of transsphenoidal surgery. Acta Neurochir (Wien). 2005 Mar;147(3):321-5; discussion 325. PubMed PMID: 15618994.

79: Vanninen RL, Manninen HI, Rinne J. Intrasellar latrogenic carotid pseudoaneurysm: endovascular treatment with a polytetrafluoroethylene-covered stent. Cardiovasc Intervent Radiol. 2003 May-Jun;26(3):298-301. PubMed PMID: 14562983.

80: Gadhinglajkar SV, Sreedhar R, Bhattacharya RN. Carotid artery injury during transsphenoidal resection of pituitary tumor: anesthesia perspective. J Neurosurg Anesthesiol. 2003 Oct;15(4):323-6. PubMed PMID: 14508174.

81: de Souza JM, Domingues FS, Espinosa G, Gadelha M. Cavernous carotid artery pseudo-aneurysm treated by stenting in acromegalic patient. Arq Neuropsiquiatr. 2003 Jun;61(2B):459-62. Epub 2003 Jul 28. PubMed PMID: 12894285.

82: Kachhara R, Menon G, Bhattacharya RN, Nair S, Gupta AK, Gadhinglajkar S, Rathod RC. False aneurysm of cavernous carotid artery and carotid cavernous fistula: complications following transsphenoidal surgery. Neurol India. 2003 Mar;51(1):81-3. PubMed PMID: 12865528.

83: Steinhart H, Ruberg F, Steudel I, Iro H. [Advanced transfacial approach to extensive sellar adenoma of the pituitary gland]. HNO. 2003 Mar;51(3):234-8. German. PubMed PMID: 12627252.

84: Yamasaki T, Moritake K, Nagai H, Kimura Y. Integration of ultrasonography and endoscopy into transsphenoidal surgery with a “picture-in-picture” viewing system–technical note. Neurol Med Chir (Tokyo). 2002 Jun;42(6):275-7; discussion 278. PubMed PMID: 12116536.

85: Kocer N, Kizilkilic O, Albayram S, Adaletli I, Kantarci F, Islak C. Treatment of iatrogenic internal carotid artery laceration and carotid cavernous fistula with endovascular stent-graft placement. AJNR Am J Neuroradiol. 2002 Mar;23(3):442-6. PubMed PMID: 11901015.

86: Kadyrov NA, Friedman JA, Nichols DA, Cohen-Gadol AA, Link MJ, Piepgras DG. Endovascular treatment of an internal carotid artery pseudoaneurysm following transsphenoidal surgery. Case report. J Neurosurg. 2002 Mar;96(3):624-7. PubMed PMID: 11883853.

87: Kim SH, Shin YS, Yoon PH, Kim DI. Emergency endovascular treatment of internal carotid artery injury during a transsphenoidal approach for a pituitary tumor –case report–. Yonsei Med J. 2002 Feb;43(1):119-22. PubMed PMID: 11854942.

88: Cappabianca P, Briganti F, Cavallo LM, de Divitiis E. Pseudoaneurysm of the intracavernous carotid artery following endoscopic endonasal transsphenoidal surgery, treated by endovascular approach. Acta Neurochir (Wien). 2001;143(1):95-6. PubMed PMID: 11345725.

89: Kai Y, Hamada J, Nishi T, Ushio Y. [Successful treatment with bypass and interventional surgery for a ruptured pseudo carotid artery aneurysm after transsphenoidal surgery: a case report]. No Shinkei Geka. 2001 Mar;29(3):241-5. Review. Japanese. PubMed PMID: 11321793.

90: Cockroft KM, Carew JF, Trost D, Fraser RA. Delayed epistaxis resulting from external carotid artery injury requiring embolization: a rare complication of transsphenoidal surgery: case report. Neurosurgery. 2000 Jul;47(1):236-9. PubMed PMID: 10917369.

91: Bizri AR, al-Ajam M, Zaytoun G, al-Kutoubi A. Direct carotid cavernous fistula after submucous resection of the nasal septum. ORL J Otorhinolaryngol Relat Spec. 2000 Jan-Feb;62(1):49-52. Review. PubMed PMID: 10654318.

92: Dolenc VV, Lipovsek M, Slokan S. Traumatic aneurysm and carotid-cavernous fistula following transsphenoidal approach to a pituitary neuroendocrine tumor: treatment by transcranial operation. Br J Neurosurg. 1999 Apr;13(2):185-8. PubMed PMID: 10616589.

93: Dolenc VV. Extradural approach to intracavernous ICA aneurysms. Acta Neurochir Suppl. 1999;72:99-106. PubMed PMID: 10337417.

94: Kuchiki H, Katakura K, Kinjo T, Sato K, Kayama T. [Transsphenoidal surgery and gamma-knife radiosurgery for a treatment of recurrent craniopharyngioma with moyamoya vessels]. No Shinkei Geka. 1998 Mar;26(3):273-8. Japanese. PubMed PMID: 9558661.

95: Raymond J, Hardy J, Czepko R, Roy D. Arterial injuries in transsphenoidal surgery for pituitary neuroendocrine tumor; the role of angiography and endovascular treatment. AJNR Am J Neuroradiol. 1997 Apr;18(4):655-65. PubMed PMID: 9127026.

96: Bavinzski G, Killer M, Knosp E, Ferraz-Leite H, Gruber A, Richling B. False aneurysms of the intracavernous carotid artery–report of 7 cases. Acta Neurochir (Wien). 1997;139(1):37-43. PubMed PMID: 9059710.

97: Yamasaki T, Moritake K, Hatta J, Nagai H. Intraoperative monitoring with pulse Doppler ultrasonography in transsphenoidal surgery: technique application. Neurosurgery. 1996 Jan;38(1):95-7; discussion 97-8. PubMed PMID: 8747956.

98: Koltai PJ, Goufman DB, Parnes SM, Steiniger JR. Transsphenoidal hypophysectomy through the external rhinoplasty approach. Otolaryngol Head Neck Surg. 1994 Sep;111(3 Pt 1):197-200. PubMed PMID: 8084625.

99: Matsuno A, Yoshida S, Basugi N, Itoh S, Tanaka J. Severe subarachnoid hemorrhage during transsphenoidal surgery for pituitary neuroendocrine tumor. Surg Neurol. 1993 Apr;39(4):276-8.

PubMed PMID: 8488444.

100: Ahuja A, Guterman LR, Hopkins LN. Carotid cavernous fistula and false aneurysm of the cavernous carotid artery: complications of transsphenoidal surgery. Neurosurgery. 1992 Oct;31(4):774-8; discussion 778-9. Review. PubMed PMID: 1407467.

101: Ledić S, Vujicić M, Citić R, Sekulović S. [Closed intracranial extradural traumatic lesions of the internal carotid artery]. Vojnosanit Pregl. 1992 Jul-Aug;49(4):317-24. Serbian. PubMed PMID: 1481444.

102: Moriyama T, Shigemori M, Hirohata Y, Konishi J, Tokunaga T, Kuramoto S. [Multiple intracranial aneurysms following radiation therapy for pituitary adenoma; a case report]. No Shinkei Geka. 1992 Apr;20(4):487-92. Review. Japanese. PubMed PMID: 1570076.

103: Reddy K, Lesiuk H, West M, Fewer D. False aneurysm of the cavernous carotid artery: a complication of transsphenoidal surgery. Surg Neurol. 1990 Feb;33(2):142-5. PubMed PMID: 2305358.

104: Riederer A, Wilmes E. [A rare complication of septum surgery: internal carotid artery-cavernous sinus fistula]. Laryngol Rhinol Otol (Stuttg). 1987 Nov;66(11):583-5. German. PubMed PMID: 3695772.

105: Britt RH, Silverberg GD, Prolo DJ, Kendrick MM. Balloon catheter occlusion for cavernous carotid artery injury during transsphenoidal hypophysectomy. Case report. J Neurosurg. 1981 Sep;55(3):450-2. PubMed PMID: 7264735.

1)

Haley M, Kumaria A, Lenthall R, McConachie N, Smith S, Dow G. Coughing on the coil; a case report and literature review of eight cases of endovascularly treated ICA pseudoaneurysms with coil migration into the oropharnyx. Br J Neurosurg. 2020 Jan 29:1-3. doi: 10.1080/02688697.2020.1716944. [Epub ahead of print] PubMed PMID: 31994916.