|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Study | Age | Gender | PMHx History | Procedure (Time in mins) | Sedation | Endoscopy findings and intervention | Gas used (Air/CO2) | CT findings | Echo findings | SPO2 | Heart rate | Mentation | Outcomes |
| Fang et al. (2019)31 | 67 | Male | Cardiac Carcinoma Pancreatic neuroendocrine tumor | EGD (12 mins) | Midazolam 1mg  Propafol 100mg | Anastomotic stoma 45 cm from the incisor teeth. Congestion, edema, and erosion in the mucous membrane of the anastomotic stoma were observed. | Air | Multiple air emboli in the left and right frontal and parietal lobes of the brain. Furthermore, there were diffused gas density shadows mainly at the edge of the liver | No Right-to-left shunt | Low (82%) | Brady | Loss of consciousness | Paralysis of LUE Weakness of RUE |
| Akhtar et al. (2001)32 | 80 | Female | Not mentioned | EGD (21min) | Conscious sedation | Malignant stricture at the esophagogastric junction,  along with a small esophagotracheal fistula | Not mentioned | Parenchymal air in the right hemisphere | No Right-to-left shunt | Low | Brady | Loss of consciousness | Vegetative state |
| Lopez et al. (2010)33 | 50 | Female | Hep C Cirrhosis Sheehan Syndrome | EGD | Awakened state | multiple esophageal varices grade II without gastric varices. A rupture located at 30 cm from the incisor teeth was found | Not mentioned | sulcus pneumatosis in the right parietal lobe | Not mentioned | Low (65-80%) | Brady | Loss of consciousness | Died in the next 24 hours |
| Bai et. Al (2018)34 | 61 | Female | Not mentioned | EGD | Not mentioned | Esophageal varices with signs of recent bleeding Bands were placed | Not mentioned | Pneumocephalus and ischemic infarction of the right hemisphere | PFO with R-L shunt | Low | Brady | Loss of consciousness | Brain death |
| Chavalitdhamrong et al.(2013)35 | 66 | Male | Not mentioned | ERCP | Not mentioned | Not mentioned | Not mentioned | air emboli in pulmonary artery branches  air in the cerebral arterial system | left-sided intracardiac air and a patent foramen ovale | Low | Brady | Loss of consciousness | Died after severe  cerebral injury |
| Chavalitdhamrong et al.(2013)35 | 51 | Female | Pancreatic cancer | ERCP | Not mentioned | Not mentioned | Not mentioned | Not mentioned | Intra-atrial shunt | Low | Brady | Loss of consciousness | residual lower extremity deficits remained |
| Demaerel et al. (2003)36 | 80 | Male | Recurrent spinocellular carcinoma pulmonary tuberculosis | EGD | No sedation | fresh blood noted in the pharynx was attributed to the recent surgery | Not mentioned | Several areas of markedly decreased attenuation compatible with air within the sulci of the right frontal lobe | Not mentioned | Low | Brady | Loss of consciousness | residual left hemiparesis. |
| Efthymiou et al. (2012)14 | 62 | Female | Not mentioned | ERCP | Conscious sedation Midazolam 3mg   Fentanyl 200mg | Mid common bile duct (CBD) stricture with biliary dilation upstream. | Not mentioned | Pneumocephalus | Patent foramen ovale | Low | Brady | Loss of consciousness | Persistent left hemiparesis |
| Nern et al. (2012)37 | 58 | Female | Possible Cholangiocarcinoma | ERCP | Midazolam 1 mg Propofol 180 mg | Bilateral biopsy of the hepatic ducts and stenting of the common hepatic duct | Air | Air within the subarachnoid spaces most likely corresponding to embolism of superficial cortical veins predominantly within the right hemisphere including sinus sagittalis  superior with venous congestion and brain swelling Abdominal CT scan showed aerobilia and an obstruction  of the left portal vein due to the mass near the liver hilus | Patent foramen ovale | Low (89%) | Brady | Loss of consciousness | Died after sever  cerebral injury |
| Goins et al. (2010)38 | 72 | Female | Cholangiocarcinoma | ERCP (20 mins) | General anesthesia  propofol 50mg  lidocaine 75mg  rocuronium 5mg succinylcholine 60mg | Not mentioned | Not mentioned | Not mentioned | large amount of trapped air within the right heart consistent with massive air embolism | Low (~50%) | Brady | Loss of consciousness | Not mentioned |
| Kjellberg et al. 201839 | 42 | Male | Not mentioned | EGD (7 mins) | Conscious sedation Midazolam | Biopsies from distal, middle and proximal esophagus taken | Not mentioned | Massive air embolism in the right hemisphere with slight reduced attenuation in the right parietal area CT of the thorax was performed showing air around the whole length of the esophagus and small amounts of free air in the mediastinum behind the left atrium. | TTE: inconclusive TEE: Not performed due to risk of complication | Low (90%) | Brady | Loss of consciousness | Minimal left spatial disability |
| Maccarone et al. (2011)13 | 45 | Male | Not mentioned | ERCP | Not mentioned | Visualized ampulla, cholangiogram showed multiple filling defects in the common duct. | Not mentioned | Not mentioned | TEE: pulmonary outflow obstruction as well as a patent foramen ovale (PFO) | Not mentioned | Brady | Loss of consciousness | Not mentioned |
| Mcaree et al. (2008)40 | 69 | Male | Appendiceal  adenocarcinoma | EGD |  | Distal erosive esophagitis from which biopsies were taken | Not mentioned | Numerous small hypodensities consistent with air are displayed in the frontoparietal region of the right hemisphere | No evidence of  intracardiac air or shunt | Not mentioned | Brady | Loss of consciousness | Died 6 days later |
| Pandurangadu et al. (2012)41 | 71 | Male | Not mentioned | EGD | Procedural sedation | Esophageal biopsy and ablation of a duodenal arteriovenous malformation | Not mentioned | Negative for any hemorrhage or infarct, but showed evidence of multiple air/gas emboli in the right frontal lobe and frontoparietal region of the brain | No PFO | Not mentioned | Brady | Loss of consciousness | residual left-sided hemiparesis and dysarthria |
| Pee et al. (2013)42 | 84 | Female | Esophagitis Strictures above 4cm hiatal hernia | EGD | Not mentioned | Esophageal stricture Stricture was dilated with a “through the scope” CRE  fixed wire esophageal balloon dilation catheter small linear tear was noted above the balloon | Not mentioned | Pockets of air in the right cerebral hemisphere,  with slight hemorrhage in the basal ganglia. | Not mentioned | Not mentioned | Brady | Loss of consciousness | Died next day |
| Rabe et al (2006)43 | 87 | Male | Distal choledochal stenosis Adenoma of the distal bile duct | ERCP | Conscious sedation 5 mg midazolam  50 mg pethidine | Stent was found to be partially obstructed and the obstructing debris were removed using a Dormia basket and balloon catheter | Not mentioned | air within the parenchyma of the right hemisphere of the brain | PFO with R-L shunt | Not mentioned | Brady | Loss of consciousness | Residual left  sided hemiparesis |
| Rabe et al (2006)43 | 54 | Male | Chronic pancreatitis portal vein thrombosis Choledochal varices | ERCP | Not mentioned | Stenosis at and above the stent which was dilated using balloon catheter A fistula was seen extending from the bile duct at the proximal edge of the stent into the cavernous vessels | Not mentioned | multiple large venous collaterals in proximity to the biliary system. | air in the right  ventricle | Not mentioned | Brady | Loss of consciousness | Died same day |
| Raju et al. (1998)44 | 75 | Male | CAD MI COPD | EGDx4 | Conscious sedation pentazocine 50 mg midazolam 10 mg | Narrow stricture 6mm below the cricopharyngeus Second stricture was encountered in the distal esophagus through which the endoscope could not be passed. A guidewire was passed through the distal stricture into the stomach. Over the guidewire 7, 9, and 11 mm Savary dilators were passed without any complications | Not mentioned | intravascular air bubbles in the distribution of the  right middle cerebral artery; there was also cerebral atrophy, white matter disease, and an old infarction in the right parietal area | PFO with R-L shunt | Low (82%) | Brady | Loss of consciousness | peritonitis, septic shock, and death 2/2 persistant aspiration pneumonia |
| Rangappa et al. (2009)45 | 50 | Female | Not mentioned | ERCP (45 min) | fentanyl 100mg  midazolam 2mg propofol 150mg | Sphincterotomy Stone extraction with a balloon catheter was successful after several attempts and widening of the sphincterotomy to approximately 2.5 cm. Stent placement in the CBD | Not mentioned | cerebral artery gas embolism predominantly in the right hemisphere global cerebral edema with uncal and early tonsillar herniation | Air within the right atrium with a 5-mm probe Patent foramen ovale | Not mentioned | Brady | Loss of consciousness | Brain death 22hrs  after procedure |
| Stabile et al. (2006)46 | 65 | Male | Not mentioned | ERCP | Fentanyl 100mg propofol 160 mg | Calculus in the extrahepatic biliary tree | Not mentioned | intrahepatic air and massive cerebral air embolism with severe brain swelling | Not mentioned | Low (82%) | Brady | Loss of consciousness | Died 3 days later |
| Park et al. (2016)47 | 59 | Male | Gastric cancer Bone metastasis | EGD | Midazolam 2mg | Esophageal stricture at EJ anastomotic ring Balloon dilatation was chosen to achieve nutritional support | Not mentioned | Hypodense lesions indicative of air bubbles that were seen predominantly in the right hemisphere | Not mentioned | Not mentioned | Brady | Loss of consciousness | Left sided hemiparesis |
| Park et al. (2016)47 | 69 | Male | Not mentioned | ERCP/ Percutaneous biliary drainage | Midazolam 2mg | Multiple filling defects were found, and EPBD was performed to avoid bleeding due to pericholedochal varices Multiple stones were removed with a hurricane balloon dilatation catheter, and a fully covered metal stent was inserted to compress the varices. | Not mentioned | multiple wedge-shaped low-density regions in the right hemisphere (right middle, left anterior, and left posterior cerebral artery territories) | Not mentioned | Low (80%) | Brady | Loss of consciousness | Returned to baseline |
| Van boxel et al. (2010)48 | 82 | Male | Gallstone Acute cholangitis | ERCP (20mins) | Not mentioned | Not mentioned | Not mentioned | Transverse view showing air in the cerebral veins in all the cerebral territories of the right hemisphere and the middle cerebral territory of the left hemisphere Coronal view showing air in the sagittal sinus | Not mentioned | Low (70%) | Brady | Loss of consciousness | Not mentioned |
| Weber et al. 200349 | 54 | Female | Ovarian cancer w/ bone mets Left hemiparesis | EGD | Not mentioned | Esophageal bleeding caused by perforated Barret's ulcer | Not mentioned | Air-isodense spots in both hemispheres  CT of the mediastinum eight days after the detection of bilateral cerebral air embolism revealed next to the Barret’s ulcer an air-isodense esophageal second lumen leading to the pulmonary veins next to the left atrium | Normal on TEE | Not mentioned | Brady | Loss of consciousness | Returned to baseline |
| Zampeli et al. (2013)50 | 72 | Male | Cardiac adenocarcinoma w/ pulm mets (Radiotherapy) | EGD | Moderate sedation | Dilation with an over-the-scope balloon dilator | Not mentioned | Bilateral multifocal cerebral air embolism with air  bubbles within the sagittal sinus, straight sinus, great  vein of Galen, and the cerebral venous network of the cortex | Not mentioned | Not mentioned | Brady | Loss of consciousness | Died 24 hours later |
| Nayagam et al.51 | 56 | Male | Adenocarcinoma (new) | ERCP | Moderate sedation | Stricture Adenocarcinoma + Whipple's procedure performed after | Not mentioned | Positive findings of air in brain parenchymal or  pneumocephalus or presence of air in the cerebral artery | No right to left shunt | Low | Brady | Loss of consciousness | Expired |

31. Fang Y, Wu J, Wang F, Cheng L, Lu Y, Cao X. Air embolism during upper endoscopy: A case report. *Clin Endosc*. 2019;52(4):365-368. doi:10.5946/ce.2018.201

32. Akhtar N, Jafri W, Mozaffar T. Cerebral artery air embolism following an esophagogastroscopy: A case report. *Neurology*. 2001;56(1):136-137. doi:10.1212/WNL.56.1.136

33. López JC, Pérez X, Esteve F. Cerebral air embolism during upper endoscopy. *Endoscopy*. 2010;42(SUPPL. 2). doi:10.1055/s-0029-1215313

34. Bai XS, Yang B, Yu YJ, Liu HL, Yin Z. Cerebral air embolism following an endoscopic variceal ligation: A case report. *Med (United States)*. 2018;97(23). doi:10.1097/MD.0000000000010965

35. Chavalitdhamrong D, Draganov P V. Acute stroke due to air embolism complicating ERCP. *Endoscopy*. 2013;45(SUPPL.2). doi:10.1055/s-0032-1326643

36. Demaerel P, Gevers AM, De Bruecker Y, Sunaert S, Wilms G. Stroke caused by cerebral air embolism during endoscopy. *Gastrointest Endosc*. 2003;57(1):134-135. doi:10.1067/mge.2003.43

37. Nern C, Bellut D, Husain N, Pangalu A, Schwarz U, Valavanis A. Fatal Cerebral Venous Air Embolism during Endoscopic Retrograde Cholangiopancreatography - Case Report and Review of the Literature. *Clin Neuroradiol*. 2012;22(4):371-374. doi:10.1007/s00062-012-0155-0

38. Goins KM, May JM, Hucklenbruch C, Littlewood KE, Groves DS. Unexpected cardiovascular collapse from massive air embolism during endoscopic retrograde cholangiopancreatography. *Acta Anaesthesiol Scand*. 2010;54(3):385-388. doi:10.1111/j.1399-6576.2009.02144.x

39. Kjellberg A, Nyström H, Söderberg M, Dlugosz A, Jörnvall H, Steinberg A. Massive air embolism as a complication of upper gastrointestinal endoscopy: A case report illustrating a stroke mimic, literature review, and suggested management. *Clin Case Reports*. 2018;6(9):1862-1867. doi:10.1002/ccr3.1725

40. McAree BJ, Gilliland R, Campbell DM, Lucas JW, Dickey W. Cerebral air embolism complicating esophagogastroduodenoscopy (EGD). *Endoscopy*. 2008;40 Suppl 2(S 02):E191-E192. doi:10.1055/s-2007-995728

41. Pandurangadu A V., Paul JAP, Barawi M, Irvin CB. A case report of cerebral air embolism after esophagogastroduodenoscopy: Diagnosis and management in the emergency department. *J Emerg Med*. 2012;43(6):976-979. doi:10.1016/j.jemermed.2010.11.031

42. Pee L, Basu S, Loganayagam A. Cerebral air embolism: A rare complication following balloon dilation. *Endoscopy*. 2013;45(SUPPL.2). doi:10.1055/s-0032-1326251

43. Rabe C, Balta Z, Wüllner U, et al. Biliary metal stents and air embolism: A note of caution. *Endoscopy*. 2006;38(6):648-650. doi:10.1055/s-2006-925053

44. Raju GS, Bendixen BH, Khan J, Summers RW. Cerebrovascular accident during endoscopy: Consider cerebral air embolism, a rapidly reversible event with hyperbaric oxygen therapy. *Gastrointest Endosc*. 1998;47(1):70-73. doi:10.1016/S0016-5107(98)70302-5

45. Rangappa P, Uhde B, Byard R, Wurm A, Thomas P. Fatal cerebral arterial gas embolism after endoscopic retrograde cholangiopancreatography. *Indian J Crit Care Med*. 2009;13(2):108-112. doi:10.4103/0972-5229.56061

46. Stabile L, Cigada M, Stillittano D, et al. Fatal cerebral air embolism after endoscopic retrograde cholangiopancreatography [19]. *Acta Anaesthesiol Scand*. 2006;50(5):648. doi:10.1111/j.1399-6576.2006.00978.x

47. Park S, Ahn JY, Ahn YE, et al. Two cases of cerebral air embolism that occurred during esophageal ballooning and endoscopic retrograde cholangiopancreatography. *Clin Endosc*. 2016;49(2):191-196. doi:10.5946/ce.2015.071

48. Van Boxel GI, Hommers CE, Dash I, Goodman AJ, Green J, Orme RM. Myocardial and cerebral infarction due to massive air embolism following endoscopic retrograde cholangiopancreatography (ERCP). *Endoscopy*. 2010;42(SUPPL. 2). doi:10.1055/s-0029-1243826

49. Weber MA, Fiebach JB, Lichy MP, Weber R, Schwark C, Grau AJ. Bilateral cerebral air embolism [4]. *J Neurol*. 2003;250(9):1115-1117. doi:10.1007/s00415-003-0130-4

50. Zampeli E, Tsagalou E, Kanakakis I, et al. Fatal cerebral air embolism complicating esophageal dilation. *Endoscopy*. 2013;45(SUPPL2). doi:10.1055/s-0033-1344409

51. Nayagam J, Ho KM, Liang J. Fatal systemic air embolism during endoscopic retrograde cholangio-pancreatography. *Anaesth Intensive Care*. 2004;32(2):260-264. doi:10.1177/0310057x0403200217