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David Rubinstein and David Symonds

PURPOSE: To evaluate the significance of cavernous sinus gas identified on head CT scans. **METHODS:** Head CT scans were viewed prospectively for a period of 3 years. The charts of patients who demonstrated cavernous sinus gas were reviewed. **RESULTS:** Seventeen patients without head trauma and 10 patients with head trauma demonstrated gas in the cavernous sinus. None of the patients had symptoms or developed symptoms originating in the cavernous sinus. All of the patients without trauma had an intravenous line in place. Sphenoid fractures or basilar skull fractures were not a constant finding in trauma patients with cavernous sinus gas. **CONCLUSIONS:** In patients without symptoms referable to the cavernous sinus, gas in the cavernous sinus does not appear to be a significant finding. The gas is most likely the result of venous air emboli from intravenous lines or penetrating trauma.

Index terms: Cavernous sinus, computed tomography; Head, trauma

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Previously reported cases of cavernous sinus gas identified on head computed tomography (CT) scans have been associated with septic thrombosis of the cavernous sinus (1), sphenoid fracture (2), barotrauma (3), and injection of intravenous contrast through a scalp vein (4). The paucity of reports of cavernous sinus gas may reflect the fact that the finding is rare or is rarely recognized. Gas in the cavernous sinus can be easily mistaken for fat (5), and thick sections may miss the finding because of partial volume averaging of small bubbles with surrounding tissue. In addition, gas in the cavernous sinus may be mistaken for pneumatization of the anterior clinoid processes or the dorsum sellae.

Before the start of this study, the cases of septic thrombosis (1) and sphenoid fracture (2) had been reported. We discovered gas in the cavernous sinus in patients without symptoms that could be related to the cavernous sinus and in whom no obvious cause for the gas was found. Reports of the association of gas in the cavernous sinus with rather serious conditions raised concerns for these patients despite their lack of symptoms, which suggested that the gas was an incidental finding. This study was undertaken to determine whether gas in the cavernous sinus is always a significant finding.

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Materials and Methods

Head CT scans were prospectively evaluated for gas in the cavernous sinus for a period of 3 years. A scan was considered positive for gas in the cavernous sinus if a region within the cavernous sinus had a CT number less than orbital fat. Twenty-seven scans of the approximately 16 100 head CT scans performed during that time period demonstrated gas in the cavernous sinus. Cavernous sinus gas was not identified on any of the approximately 1 200 CT scans performed of the paranasal sinuses. One head CT scan that may have shown cavernous sinus gas was not included because of the possibility that the gas was in the aerated dorsum sellae. Positive scans were divided into two groups, those with a history of head trauma and those without. The locations of other gas collections were noted on all positive scans.

The charts of the patients with gas in the cavernous sinus and no history of trauma were reviewed to determine whether these patients had or developed symptoms referable to the cavernous sinus. The charts were also reviewed for the indication for obtaining the head CT scan and for possible sources of the cavernous sinus gas.

In the patients with head trauma and cavernous sinus gas, the type of trauma sustained and the location of fractures and other gas collections were recorded.

Results

Of the 17 patients without trauma, nine were female and eight were male; their ages ranged from 25 to 78 years. The indications for CT scans in the patients without trauma were varied; only one had symptoms potentially referable to the cavernous sinus (Table 1). This patient had a left sixth cranial nerve palsy, but he also had a left seventh cranial nerve palsy; both were felt to be the result of a diabetic neuropathy. None of the patients developed new symptoms referable to the cavernous sinus.

Nine of the patients without trauma had subsequent scans ranging from 5 hours to 1 year after the detection of cavernous sinus gas. One scan performed 6 hours after the detection of cavernous sinus gas demonstrated resolution of gas that had been in the right cavernous sinus and the presence of a small bubble of gas in the left cavernous sinus which had not been there previously. The remaining eight cases with subsequent scans showed resolution of the gas. These scans were performed at 5 hours, 2 days, 4 days, 5 days, 1.5 months, and 1 year after the initial scan in one patient each and 1 day after the initial scan in two cases.

One patient had gas in the infratemporal fossa and around the left vertebral artery and in the epidural space at the level of C-1.

All 17 patients without trauma had intravenous lines in place at the time of their CT scans, but only five had contrast-enhanced CT scans. Of the five patients with contrast-enhanced scans, two had noncontrast scans immediately before contrast administration. The cavernous sinus gas was unchanged between the noncontrast and contrast scans in both of these patients. All of the intravenous lines were placed before the patient arrived in the CT department, and 15 of the 17 were placed by paramedics or emergency department personnel shortly before the CT scans. All of the intravenous lines were placed in the antecubital fossa, forearm, wrist, or hand, except one subclavian line. The size of the peripheral intravenous lines was not documented in two cases and ranged from 16 gauge to 20 gauge in the other 14 patients. The exact fraction of the approximately 16 100 head CT scans that were performed on patients with intravenous lines is unknown, but we estimate that approximately 80% of the patients scanned had intravenous lines. In contrast, only about 10% of approximately 1 200 paranasal sinus CT patients had intravenous lines.

TABLE 1: Indications for CT scans

Changes in mental status	6
Transient ischemia/infarct	5
Seizures	3
Hallucinations	2
Cranial nerve palsies	1

Only one patient had a lumbar puncture before the scan, and that was 6 days before the scan. One patient had an attempted arterial puncture to evaluate oxygenation on the day of the scan, but venous blood was obtained. No other patient had an arterial puncture attempted within 3 days of the CT scan.

Of the 10 trauma patients, seven were male and three were female. They ranged from 27 to 72 years of age. Five had basilar skull fractures; only two of these involved the sphenoid bone. In three patients, penetration of the skull was secondary to surgery; for one of these the CT was obtained 6 days after surgery. Two patients had no skull fracture that could be identified on the bone windows of the routine head CT: one of these had a superficial forehead laceration; one had been hit on the head and then developed a parietal scalp abscess which was drained. The degree of trauma sustained in these two cases made clinical suspicion of skull fracture low, so no further search for fractures was conducted. In the setting of trauma, gas was also identified in the scalp (two patients), subarachnoid space (three patients), the right transverse sinus and the superior sagittal sinus (one patient), and in the infratemporal fossa and around the vertebral arteries (one patient). Only one of the trauma patients received intravenous contrast material.

Discussion

We are confident that the gas identified on the scans of patients without trauma is in the cavernous sinus and not in the subarachnoid space because these patients did not have penetrating head or spine trauma (including recent lumbar punctures) and the gas appeared medial to the lateral margin of the cavernous sinus (Fig 1). Gas within the region of the cavernous sinus could be extravascular, intraarterial, or intravenous. Without fractures of the base of the skull the gas is

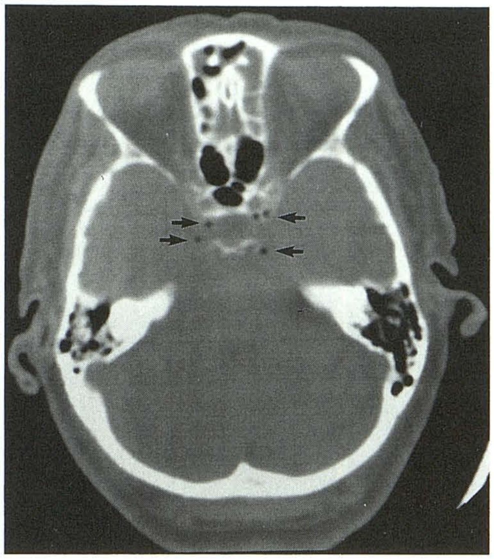


Fig. 1. Typical appearance of gas bubbles (*arrows*) in the cavernous sinus in a patient with decreased mental status and a right subclavian line. The contrast scan after this noncontrast scan showed no change in the cavernous sinus gas.

unlikely to be in or around the nerves, connective tissue, or fat that fills the nonvascular portions of the cavernous sinus. In patients with the most marked amount of gas, the bubbles appeared to outline the carotid artery (Fig 2). In addition, none of the patients had recent procedures involving arterial puncture or had evidence of right to left, shunts making location of gas in the carotid artery unlikely. In addition, only five of the patients without trauma had ischemic symptoms, which would be the expected sequela of gas within the carotid artery. Of these five, three had cardiac disease and one had carotid bulb disease responsible for the symptoms. The remaining patient, whose symptoms resolved after 2 hours, refused further evaluation.

All of the patients with cavernous sinus gas did have intravenous lines, and we feel that the gas most likely lies in the trabeculated venous spaces of the cavernous sinus. Although the majority of patients scanned had intravenous lines in place, we estimate that more than 4000 head and paranasal sinus CT scans were performed on patients without intravenous lines. If there were another source for cavernous sinus gas, we would have expected to see at least one patient with cavernous sinus gas and no intravenous line. The venous location of gas is also supported by the movement of gas from the right cavernous sinus to the left in one patient, by the resolution of the gas in less than 5 hours in one patient, and by the association of cavernous sinus gas in one patient with gas in the infratemporal fossa, the epidural space, and around the vertebral arteries where venous plexuses exist (Fig 3).

We considered repositioning patients to see whether the location of the gas would change, as might be expected with intravenous gas, but this turned out to be impractical. In all but a very few of the cases, the gas was not discovered until the patient had left the CT suite. In those few cases, the clinical condition of the patient precluded repositioning the patient. Additionally, in all but one of the patients that returned for a follow-up scan the gas had resolved.

Intravenous lines causing air emboli and the movement of intravascular gas from the upper extremity to the neck have been documented. Two reports have demonstrated that injection of contrast material for chest and neck CT scans can result in intravenous or intracardiac air because of venous air emboli (6, 7). One of these reports included two cases of air emboli in the internal jugular vein (6). We, too, have identified air in veins in the region of the clavicle, the internal jugular vein, and an anterior neck vein at the level of the hypopharynx in a supine patient who received intravenous contrast material for a neck CT scan (Fig 4). We also have seen three cases of retrograde flow of radioactive materials into the jugular vein (in one case up to the transverse sinus) on brain flow studies. Not only has the orthograde flow of intravenous gas in the arm been documented, but the retrograde flow of gas has been demonstrated from the radial artery to the subclavian artery (8, 9). The retrograde movement of air in the jugular veins into the head is, therefore, also possible and would be aided by buoyancy in an upright or partially upright patient.

The most likely route for air to course from the arm to the cavernous sinus is through the internal jugular vein and inferior petrosal sinus. On this route the gas would pass through the largest vessels with the most vertical course, which would maximize the chance of air reaching the cavernous sinus because of buoyancy and minimize the chance of the air being trapped in a small lumen. Once the air has passed through the inferior petrosal sinus, an air bubble may lodge within the trabeculated venous spaces which comprise one of the cavernous sinuses. The air bubble also could be trapped in the anterior or posterior intercavernous sinus, which together with the cavernous sinus constitute the circular sinus. Air which courses into neck veins other

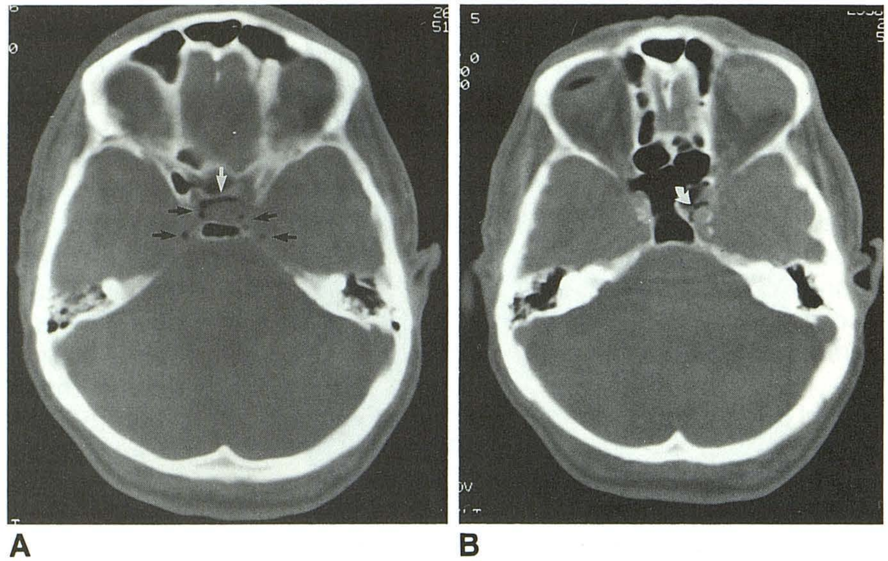


Fig. 2. *A,* Gas in the cavernous sinuses (*black arrows*) and anterior intercavernous sinus (*white arrow*) in a patient with decreased mental status and a peripheral intravenous line started by the paramedics.

B, Some of the gas (*curved white arrow*) outlines the medial and anterior border of the partially calcified left internal carotid artery. Only a noncontrast scan was performed.

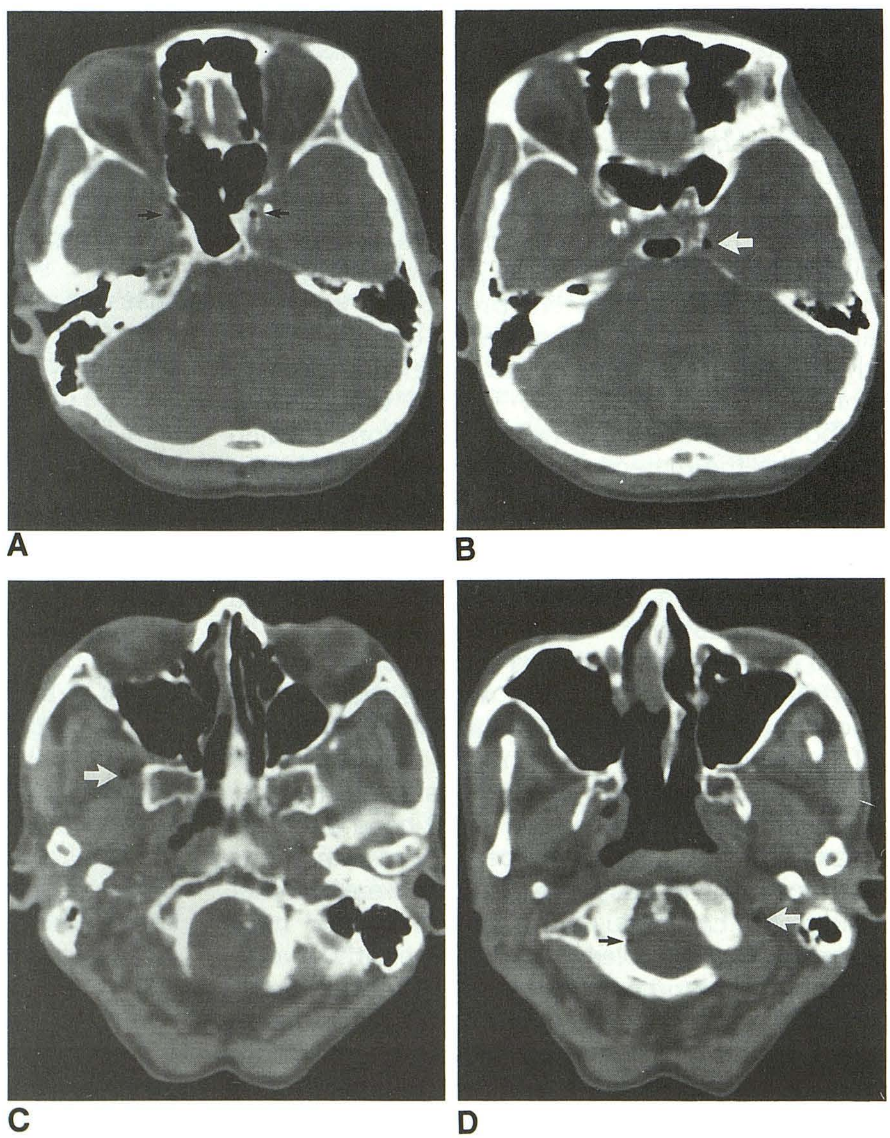
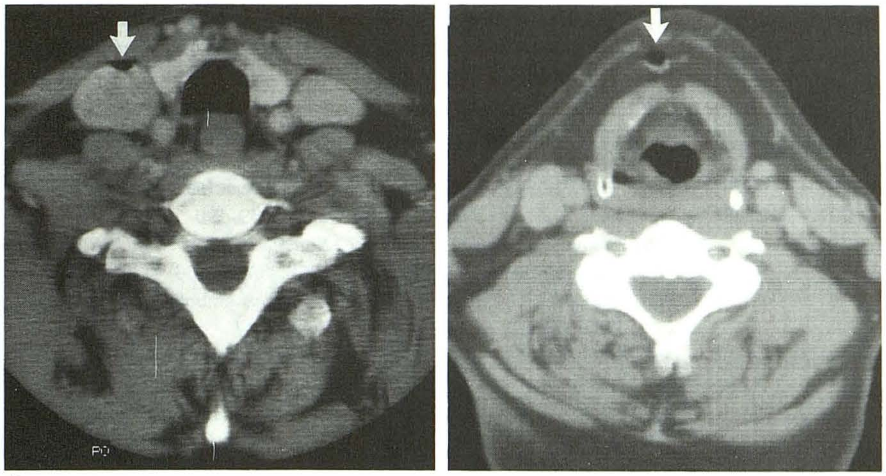


Fig. 3. Gas (*arrows*) in the cavernous sinuses (*A* and *B*) in a patient who also had gas (*arrows*) in the right infratemporal fossa (*C*) and near the left vertebral artery and in the C-1 epidural space on the right (*D*). This patient had left arm weakness and a peripheral intravenous line started by the paramedics. No contrast material was given.



A B

Fig. 4. Gas (*arrows*) in the right internal jugular vein (*A*) and in an anterior neck vein (*B*) after the injection of intravenous contrast through a peripheral intravenous line started for this neck CT. The scan was performed to evaluate a suspected neck mass.

than the internal jugular vein or which leaves the internal jugular vein before reaching the inferior petrosal sinus may become lodged in small-caliber veins including the pterygoid plexus, the plexus of veins around the vertebral arteries, and the plexus of veins in the epidural space of the spinal canal (Fig 3).

The location of the gas in the trauma patients is less clear. The potential for confusion with subarachnoid gas exists, and the possibility of extravascular gas exists in the two patients with sphenoid fractures. In the patients with penetration of the skull distant from the sphenoid bone and in the patients without fractures, the gas is most likely in the venous spaces. Identification of gas, near the vertebral arteries and infratemporal fossa in one patient with parietal burr holes and in the superior sagittal sinus and transverse sinus in a patient with a sphenoid fracture, supports an intravenous location of the gas. Intravenous cavernous sinus gas in trauma patients may originate from penetrating trauma or intravenous lines.

Only one of our 27 patients and only one of four previously reported cases (1–4) had symptoms referable to the cavernous sinus. In our patient, the symptoms were attributable to a diabetic neuropathy which affected the patient's sixth and seventh cranial nerves. In the reported case of septic thrombosis (1), the patient's symptoms were most likely caused by septic thrombosis of the cavernous sinus and not the presence of gas. Therefore in none of our cases and in none of four previously reported cases did gas in the cavernous sinus cause symptoms.

In the reported cases of septic thrombosis (1) and barotrauma (3) associated with cavernous sinus gas, the gas may have been introduced through intravenous lines and may not have been related to the patients' underlying conditions. If the gas in those cases was caused by intravenous lines then all of the known cases of cavernous sinus gas in patients without trauma are incidental findings. If the gas in those two cases was truly caused by the septic thrombosis and barotrauma, then the finding of cavernous sinus gas was not incidental in only two of the 20 cases reported with cavernous sinus gas and without trauma. The diagnosis of septic thrombosis of the cavernous sinus was made from other findings, and the presumed barotrauma was not treated. So in none of the cases was the finding of cavernous sinus gas significant in influencing the treatment of a patient. Cavernous sinus gas in a trauma patient, however, may be significant as a sign of skull fracture.

Although previous reports have stressed the injection of intravenous contrast material as a source of venous air emboli (4, 6, 7), only five of the 17 nontrauma patients and one of the 10 trauma patients received contrast material for their CT scans. In two of these patients the gas was present on a precontrast scan, leaving only four cases in which the injection of intravenous contrast material may have been responsible for the cavernous sinus gas. Our data indicate that contrast injection is not the major cause of cavernous sinus gas and that any intravenous line may be responsible for venous air emboli. Furthermore, 15 of the 17 nontrauma patients had intravenous lines that were started shortly before the CT scans, suggesting that venous air emboli may be more likely to occur when an intravenous line is being established.

Like small venous air emboli from contrast injection (4, 6, 7), cavernous sinus gas causes no harm. In patients without a history of head trauma and without symptoms referable to the cavernous sinus, gas in the cavernous sinus is most likely an incidental finding caused by venous air emboli from intravenous lines. In trauma patients the gas in the cavernous sinus region may be extravascular, caused by a sphenoid fracture, or intravenous, caused by venous air emboli from penetrating head trauma or an intravenous line.

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