CHAPTER 11

A RARE IATROGENIC COMPLICATION ASSOCIATED WITH IV LINES

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Intravascular catheters (IVCs) are the commonly used medical devices in hospital settings. They may be intravenous ot intraarterial depending on the patient need. Their uses increase dramatically in the intensive care units (ICUs) **(1).** In many situations they are essential way for both treatment and for diagnosis. Although their benefits for the patient is clear, there are also important conserns about risk of complications associated with high morbidity and mortality. Catheter related infections are the most known of these potentially dangerous complications **(2).** In addition, failure of the catheter before the end of the treatment due to thrombosis or accidental removal of the catheters are also possible problems in hospitalized patients. Apart from these well known possible adverse events which may be related with IV catheters, another rare but potentially fatal complication that may also occur in association with these medical devices is cerebral air embolism (CAE). CAE is often iatrogenic. CAE can be within the arterial or venous systems. Furthermore, the air bubbles can enter both the venous or arterial systems. This may occur directly or it appears as a paradoxical phenomenon with a venous air embolus entering the arterial system via a right-to-left shunt. The arterial CAE may be caused by trauma, surgery (especially cardiothoracic/neurosurgery), procedures (e.g. arterial line, lung biopsy). The air bubbles are seen in the intracranial arterial vasculature in this case. The venous CAE is caused during manipulation ov venous lines. In this chapter cerebral venous air embolism (CVAE) will be discussed by demonstrating a radiological example.

Cerebral Venous Air Embolism (CVAE)

It is a potentially serious complication of various medical procedures performed in almost all clinical specialties such as in neurosurgery during posterior fossa operations or invasive pulmonary procedures (eg. percutaneous lung biopsy). In addition, it may also occur in association with intravenous (IV) catheterization. More often, it is seen after manipulations (during the placement or removal) of

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central venous catheters (CVCs) rather than a peripheral IV line **(3-5).**However, although rare it may also occur in association with a peripheral IV line **(6,7)**

PATHOPHYSIOLOGY

In the pathophysiology, CVAE occurs when the air bubbles overcome the gradient between the external atmospheric pressure and the intravenous pressure to enter the blood stream. This retrograde passage of air bubbles was first described in a letter to the editor by Ploner et al in 1991 **(8).** The resulted pneumocephalus preasumbly due to IV injection of air is an uncommon phenomenon. Pneumocephalus also known as pneumocranium is the presence of air or gas within the cranium. The distribution of air bubbles may be either extraaxial (epidural, subdural, subarachnoid) or intraaxial (parenchymal, intraventricular, intravascular). Localization of the air bubbles to a specific compartment and assessment of the entryway is important in diagnosis and management of the patients.

Clinical presentattion

The clinical presenattion is usually asymptomatic or nonspecific sysmptoms such as headeache, nausea, vomiting, vertigo and confusion may be present. However, depending on the volume and territory of the air bubbles in the cerebral vasculature, the clinical presentation and severity of the situation vary and therefore more severe neurological findings such as decreased consciousness or seizure are also possible. A serious adverse event which may be associated with CVAE is that it can react as a thrombotic emboli and by occluding the end arteries it may cause ischemic stroke **(6).** Cerebral edema can also develop.

Anatomical point of view

Unlike the systemic venous system, cerebral venous system does not precisely follow the cerebral arterial system. The cortical veins lie superficially and drain to the nearest dural venous sinuses **(10).** Dural venous sinuses are connected to each other via various venous plexuses. TRhese include

- cervical epidural venous plexus,
- vertebral venous plexus that surrounds the vertebral artery in the transverse foramen or
- venous plexus of the hypoglossal canal.

The emissary veins provide a venous communication between the dural venous sinuses and the extracranial venous system by passing through foramina in the skull **(11).**

CVAE is assumed to be resulted from retrograde progression of low weight air bubbles through the subclavian vein into the jugular vein against to the blood flow. The air bubbles then pass into the dural venous sinuses. The air volume, the type of medical procedure and the position of the patient are among contributing factors. For example, jugular vein insufficiency, increased intrathoracic pressure during valsalva maneuvers, and low flow states like in heart failure may result in venous air embolism **(3).** Venous air embolism can also involve the cerebral arterial vasculature by paradoxical air embolus with the entry of the air from the venous system to the arteries via a right-to-left shunt, such as a patent foramen ovale **(4).** In the patient demonstrated in the figures, it seems that after traversing the subclavian vein and reaching the internal jugular vein (IJV), air bubbles migrated on a retrograde course and arrived to the right sigmoid and transverse sinuses. From the IJV, they also migrate through the inferior petrosal sinus to enter the cavernous sinuses and then the ophtalmic veins. Epidural venous air embolism (pneumorrhachis) located in the cervical epidural venous plexus can be explained with its connections to the sigmoid sinus within the skull. This venous plexus also have a connection with the vertebral venous plexus via a venous network at the level of foramen magnum. Epidural venous air embolism has been more frequently described as a complication of epidural anesthetic procedures causing injury of the plexus and resulting in the inadvertent entry of the air into the veins **(12).** The air bubbles associated with the venous plexus of the hypoglossal canal in our case could be provided via its relation with the cervical epidural venous plexus, the inferior petrosal sinus and also the IJV **(11).** The extracranial air bubbles in the right pterygoid venous plexus and the right superficial temporal vein was thought to be migrated from the dural venous sinuses via emissary veins. In our case, we thought that the emissary vein of Vesalius which is a well known important route for spread of infections to the cavernous sinuses, was responsible for the passage of air from the cavernous sinuses into the pterygoid venous plexus and the superficial temporal vein **(13).**

Radiological point of view

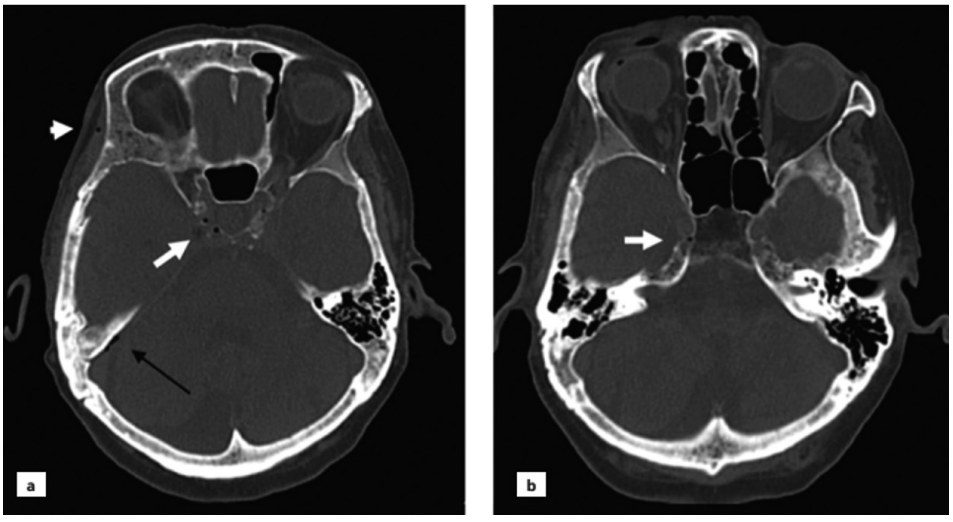
The most useful radiological imaging modality to detect intracranial air bubbles is conventional CT scan without contrast. However, as air is absorbed rapidly, it may be only diagnostic in the acute period **(9).** Air bubbles appear as extremely dark with Hounsfield unit (HU) of around – 1000. Intracranial lipomas have a similar contrast in parenchymal window, but can easily be differentiated by their lower HU (-50 to – 100). In the patient demonstrated in figures , there was a small midline lipoma adjacent to the falx cerebri with HU of average – 61, which has similar

contrast with the air within the right transverse sinüs. Moreover, the distribution of the air bubbles is highly variable acccording to the severity of the situation and anatomical variations of the venous system.

In complicated cases cerebral infarction may be seen and in some cases it may be the only visible change due to the reabsorption of the air bubbles with time.

Magnetic resonance imaging (MRI) is not used to detect air bubbles, but in cases complicated with infarction MRI with diffusion weighted imaging (DWI) is used.

An example of CVAE is shown on CT images below.



In a case of pneumocephalus, in the absence of trama and associated fracture involving the cranial vault or air spaces of the head, the pneumocephalus can be due to iatrogenically. The distribution of air bubbles is important in making diagnosis. In this case, the non-enhanced cranial CT shows that (a) air bubbles are in the cavernous sinus (white arrow), right sigmoid sinus (black arrow) and right superficial temporal vein (short white arrow); (b) air bubbles in the right inferior petrosal sinus (white arrow). That is, gas is located in the intracranial venous structures. In such presentation, the presence of recent manupulation of IV catheters in history should be queried. In this patient, IV injection of air through the peripheral venous catheterization performed two days ago due to diuretic administration fordecompensated heart failure is preasumed. In this patient the presentation was 2 days after IV catheter manupulation and the presentation was with headache. The CT findings were demonstrated. The symptoms were resolved by Trendelenburg position and 100% oxygen theraphy.

TREATMENT

The treatment of CVAE consists of Trendelenburg positioning to facilitate the return of air bubbles into the central venous system and high concentration (100%) oxygen to reduce the volume of air in the circulation. Hyperbaric oxygen therapy should be considered for more severe cases **(2).** Intravascular volume expansion to prevent further entry of air into the circulation may be considered in appropriate settings. In our patient, with the consideration of her recent and ongoing congestive status, IV hydration was not administered. In addition, avoidance of Valsalva maneuver like coughing or forceful sneezing in order not to increase the intratoracic pressure is recommended. Our patient became symptom free with improvement of the complaints without any deterioration in her clinical status during the follow up at the emergency department. CVAE is an unusual but potentially serious complication of various medical procedures. It may occur even after injection of IV fluids at routine peripheral venous lines and result in widespread air bubbles in various locations of the cerebral venous vasculature, as in our case. It should be considered in differential diagnosis of nontraumatic headache and vomitting especially when there is a recent insertion of venous catheters (central or peripheral). CT is gold standard in early diagnosis and management especially during acute phase.

Therefore, prevention should be the priority by properly positioning the patients and keeping the lumens of venous catheters filled with saline prior to any manipulations.

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