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Massive Head Trauma as a Cause of Intravascular Air

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ABSTRACT: Three examples of intravascular air caused by massive head trauma are presented. The basic types of air embolism are discussed and the pathophysiology in the three cases is offered. The association should be recognized to avoid misinterpretation of the radiographs.

KEYWORDS: pathology and biology, embolisms, injuries, air embolisms, pulmonary embolisms, skull trauma, postmortem radiography

Postmortem Diagnosis

The use of postmortem radiography, as reported in the radiographic literature, has essentially been limited to identification purposes [*1,2*]. Forensic pathologists, however, use radiographic evaluation not only for identification but also in a variety of other forensic science situations [*3-8*]. This paper presents three examples of extensive intravascular air identified on postmortem radiographs of patients who died as a result of massive head injuries. Both the radiologist and the forensic pathologist need to be aware of this association to avoid incorrect radiographic interpretations. The pathophysiology of air embolism is reviewed and discussed.

Case Reports

Case 1

A young male was brought to the emergency room (ER) and pronounced dead on arrival. The cause of death was a self-inflicted .45 caliber gunshort wound to the right temple (Fig. 1). An anteroposterior (AP) chest film (Fig. 2) demonstrates extensive intravascular air outlining the jugular vein, superior vena cava, and right atrium.

Case 2

A young male was pronounced dead at the scene, a victim of a self-inflicted gunshot wound to the right temple. A lateral view of the skull (Fig. 3) demonstrates extensive calvarial fracturing as well as air outlining the sigmoid sinus and cervical veins. An AP view of the chest (Fig. 4) demonstrates extensive intravascular air.

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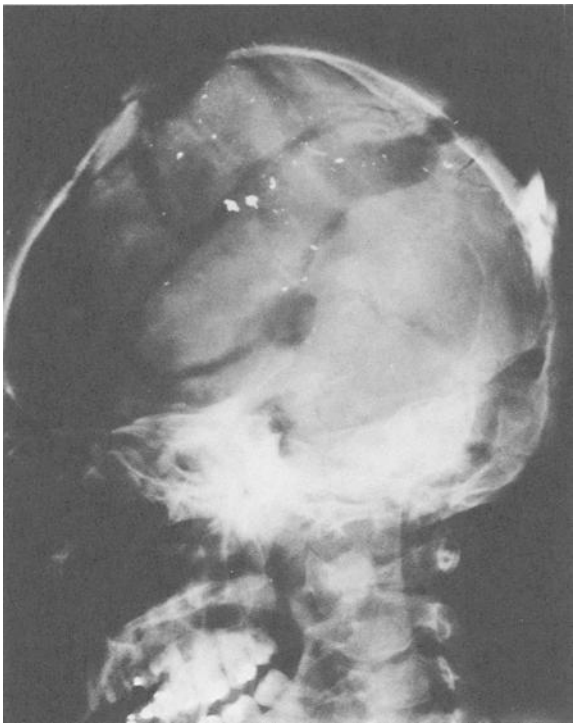

FIG. 1—*The lateral view of the skull demonstrates the extensive fracturing that occurs with large caliber weapons.*

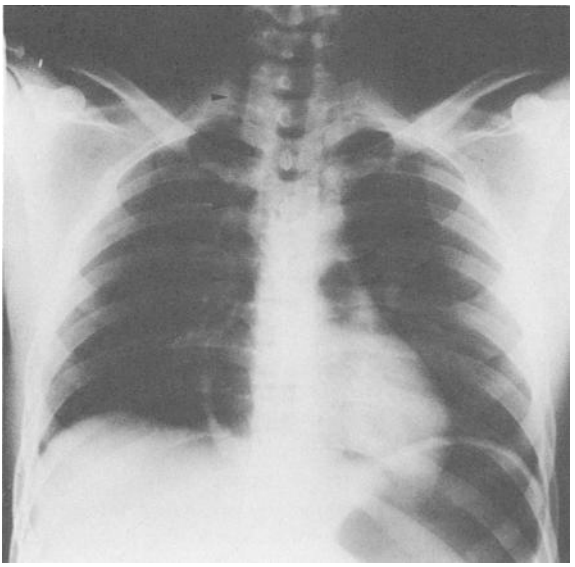

FIG. 2—*AP view of the chest showing air outlining the right jugular vein, superior vena cava, and right atrium* (small arrowheads). *There is also air filling the pulmonary outflow tract* (large arrowheads).

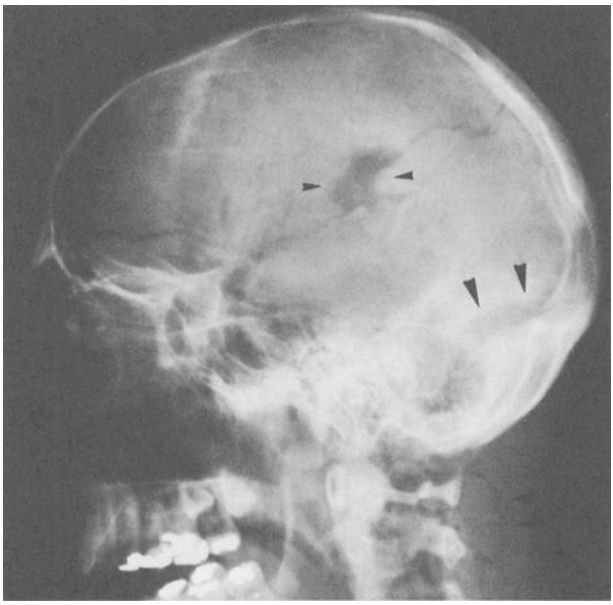

FIG. 3—*The lateral view of the skull shows a large exit wound* (small arrowheads) *with accompanying calvarial fractures. Air outlines the transverse sinus as well as cervical veins* (large arrowheads).

Case 3

A young male was involved in a vehicular accident and suffered skull lacerations and fractures. A brief unsuccessful resuscitative effort was made in the ER. Postmortem radiographs (Figs. 5 and 6) demonstrated intravascular air.

Discussion

The accumulation of air in the soft tissues and vessels of a dead body occurs as part of the normal putrefactive process from gas forming organisms such as *Clostridium welchii*. This gas forms as small bubbles which coalesce and dissect along fascial planes. It can also accumulate uniformly in both the arterial and venous systems. Such gas formation is demonstrated in the postmortem radiograph (Fig. 7) of a drowning victim whose body was not recovered for 40 h. The amount of gas formed depends on a number of factors, including the presence of penetrating wounds that allow bacteria to enter the body, relative humidity, and ambient temperature. As the ambient temperature increases, the putrefactive process accelerates rapidly. Conversely a body subjected to extremely low temperatures may demonstrate little or no decomposition for extended periods of time.

Intravascular air as a cause of death has been described in a number of clinical and surgical settings dating back to the early 19th century [*9*]. Most of these early reports were complications of head and neck surgery. The sudden death associated with thoracic wall puncture and empyema cavity lavage was originally felt to be a shock reaction, related to the enervation of the thoracic wall. It was not until the early 20th century that air embolism was appreciated as being the causative factor in these deaths as well [*10,11*]. Westcott reported a case of fatal air embolism complicating percutaneous needle biopsy of the lung and emphasized the importance of the distinction between peripheral venous and pulmonary venous air emboli [*12*].

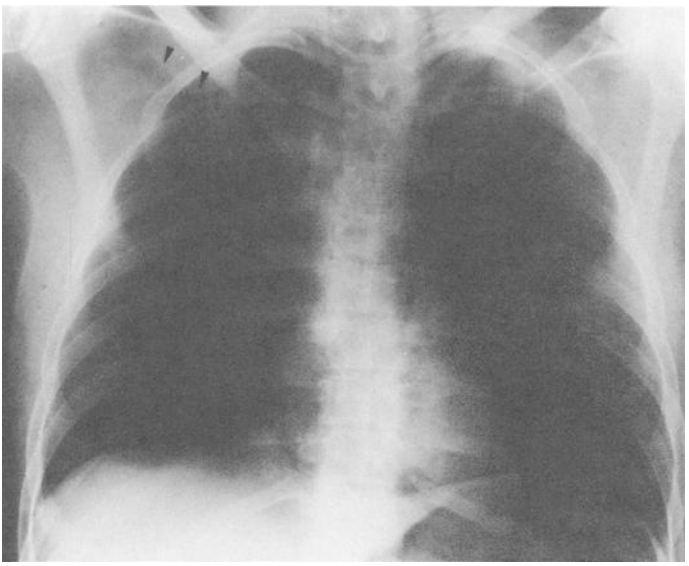

FIG. 4—*The AP view of the chest shows air outlining the right subclavian vessels* (small arrowheads). *Air is also seen in the superior vena cava and right atrium* (large arrowheads).

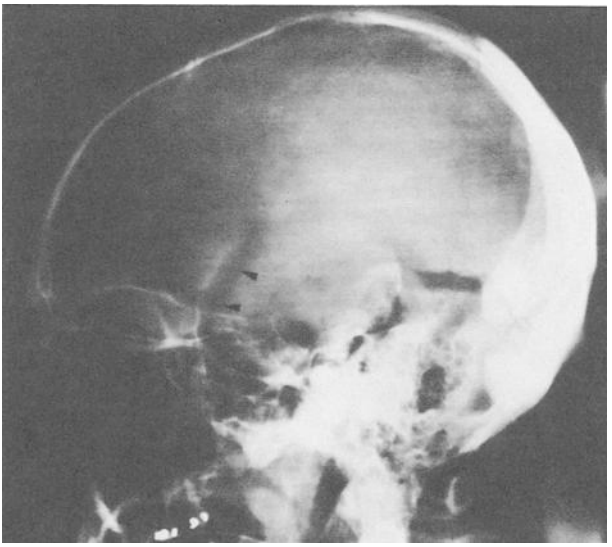

FIG. 5—*The lateral view of the skull demonstrates a diastatic fracture extending across the transverse sinus. Intracranial air is seen in the middle cranial fossa* (small arrowheads).

In a general sense there are two basic types of air embolus, namely pulmonary (venous) and arterial. In the pulmonary type air enters the venous system and is carried back to the heart and into the pulmonary bed. Up to 100 cm^3 of air can be handled by the body without fatality, particularly if the air is introduced slowly [*13*]. Arterial air emboli occur when air enters the left side of the heart and escapes into the systemic and coronary arteries. This is a

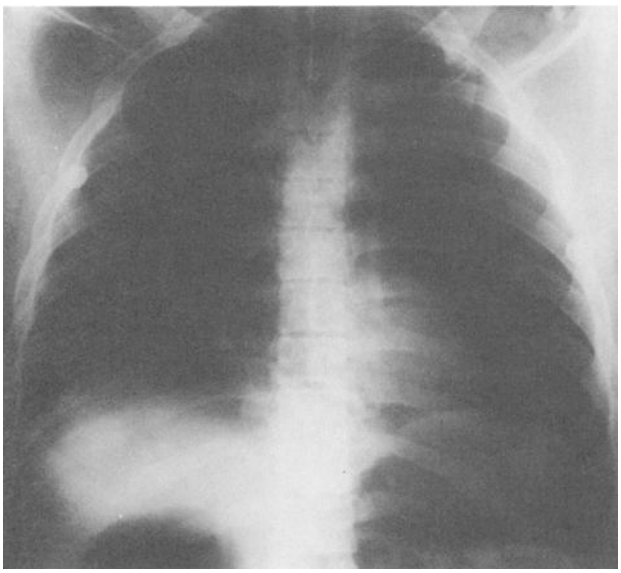

FIG. 6—*The AP view of the chest shows air outlining the superior vena cava and right atrium* (small arrowheads).

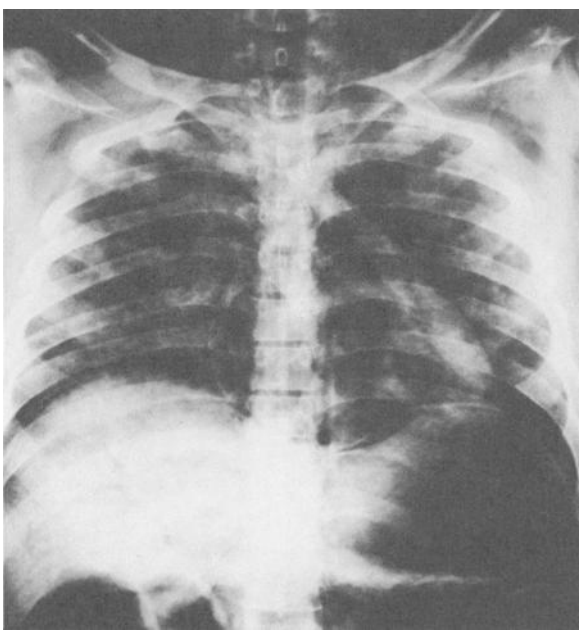

FIG. 7—*The AP view of the chest shows extensive soft tissue and intravascular air. In addition there is intracardiac air as well as air within the liver and intestinal wall.*

more deadly complication with as little as 2 to 3 mL of air causing death experimentally in animals [*14,15*]. This disparity in the clinical picture is due to air entering the coronary arteries causing arrhythmias and entering the cerebral vascular tree causing cerebral insufficiency. Venous air can enter the arterial side through a patent foramen ovale or from penetrating lung trauma [*16-20*].

There are a number of excellent reviews in the literature which discuss the myriad causes of both venous and arterial air emboli [*21-23*]. One of the more common situations in which the clinician encounters this problem is in the case of neurosurgical or head and neck surgery [*24-26*]. The mechanism of injury in these cases is related to the negative pressure in the vascular tree which allows air to be drawn into the veins when the patient is in the sitting position. There is a 1.6 to 15% incidence of air embolus in neurosurgical procedures and a variety of intraoperative maneuvers and monitoring devices have been developed to decrease the occurrence of this complication [*27,28*]. Air embolus from cardiopulmonary bypass is also a well recognized complication [*29,30*].

The occurrence of intravascular air with head trauma has been noted incidentally in the forensic science literature. Erben [*13*] refers to an eleven-year-old boy who was struck in the head by an iron railing. In addition to the skull fractures, 65 mL of air were found in the right heart. This air was attributed to the extensive open fracture of the parietal bone and disruption of the diploic veins. Schmidt [*8*] mentions that severe air embolism after polytrauma will be seen frequently although no specific percentages were given. The three cases presented in this paper are felt to have a similiar pathophysiology. Large caliber gunshot wounds to the head cause extensive fracturing and lacerations which can extend across dural venous channels that do not collapse. Cardiac activity can continue for several minutes and as the blood drains back to the heart air enters the venous system. As the amount of venous air increases, intravascular clotting and obstruction occurs and is a causative factor in the eventual cessation of cardiac activity. The presence of this air exclusively in the venous chennels differentiates it from the type of air seen in the normal putrefactive process as illustrated in Fig. 7, a distinction that is important for the forensic pathologist.

The role that the radiologist plays in the forensic science investigation of death should not be limited merely to that of identification purposes. Knowledge of the association of intravascular air and massive head trauma should help the radiologist avoid errors in interpretation in such cases and make him a more valued consultant to the forensic pathologist.

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