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Post-mortem fluid stasis in the sinus, trachea and mainstem bronchi; a computed tomography study in adults and children

S. Biljardt [a], A. Brummel [a], R. Tijhuis [a], T. Sieswerda-Hoogendoorn [b], L.F. Beenen [b], R.R. van Rijn [b,c,d,*]

[a] Medical Technology Group, Inholland University of Applied Sciences, Haarlem, the Netherlands
[b] Department of Radiology, Academic Medical Center Amsterdam, Amsterdam, the Netherlands
[c] Department of Forensic Medicine, Netherlands Forensic Institute, the Hague, the Netherlands
[d] Amsterdam Center for Forensic Science and Medicine, Amsterdam, the Netherlands

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ABSTRACT

Introduction: The purpose of this study was to assess occurrence of fluid stasis in the sinus, trachea and mainstem bronchi on PMCT.
Materials and methods: Patients were collected from different groups, two adult and two paediatric groups. Patients who died from drowning or evident trauma to head and neck were excluded.
Results: Adults

Two-hundred-and-one PMCT scans, 118 (59%) males and 83 (41%) females. Age was known for 185/201 subjects (92%), median was 79 years (IQR 66–85 years).

The frontal sinus contained fluid in 13/194 (7%), the left maxillary sinus contained fluid in 31/198 (16%), the right in 42/198 (21%). In 19/201 (9%) fluid was present in the trachea at the level of the subglottis, in 37/201 (18%) at the midlevel, 72/201 (36%) at the carina, 91/201 (45%) at the left and in 82/201 (41%) at the right mainstem bronchus.
Children: Seventy-seven PMCT scans, 42 (55%) boys and 35 (45%) girls. median age was 0.5 years (IQR 3 months–6 years).

The frontal sinus contained fluid in 3/76 (4%), the left maxillary sinus in 14/52 (27%), the right in 13/52 (25%), in 18/77 (24%) fluid was present in the trachea at the subglottic level, in 32/77 (42%) at the midlevel, in 36/77 (47%) at the level of the carina, in 34/77 (44%) at the left and in 37/77 (48%) at the right main stem bronchus.
Conclusion: The presence of fluid in the sinuses, trachea and/or mainstem bronchi Is common in non-drowning cases and Is a normal finding in PMCT.

1. Introduction

With the increasing utilisation of post-mortem CT (PMCT), it is important to know how to interpret PMCT findings [1,2]. For example, during life the presence of intra-vascular air represents a pathological condition, although after the onset of death it represents the decomposition of the body and in most cases has no relationship with the cause of death.

Another topic that has been reported, is the presence of fluid in the sinuses and airways. During life this could represent a (clinically relevant or not relevant) sinusitis or post-traumatic blood and post-mortem it has been suggested to be caused by drowning [3–9]. Furthermore, the presence of fluid stasis in the airways could be caused by normal post-mortem changes. As PMCT is used to determine cause of death, especially in the forensic setting where drowning is a possible cause of death, differentiation between either drowning and sinusitis or physiological post-mortem changes is relevant to enhance uniform reporting and improve the quality of causes of death established with PMCT.

If it was known in what percentage of non-drowned cases post-mortem fluid stasis is present in the airways, this could help to determine the predictive value of PMCT for the diagnosis of drowning. We designed a study in which we analysed the presence of fluid stasis in sinuses, trachea and mainstem bronchi of adults and children who died of natural causes of death (adults) and both natural and non-natural causes of death (children) but in whom drowning or submersion was excluded. Furthermore we

* Correspondence to: Department of Radiology, Emma Children's Hospital-Academic Medical Center Amsterdam, Meibergdreef 9, 1105 AZ Amsterdam, the Netherlands.
E-mail address: r.r.vanrijn@amc.uva.nl (R.R. van Rijn).

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will describe the percentage of filling of the different lumina and the Hounsfield Units for the different fluids.

2. Materials and methods

2.1. Patients

Patients for this retrospective study were collected from four different groups. There are two groups of adult patients and two groups of paediatric patients. This retrospective study was approved with a waiver for retrospective imaging research by the internal review board of the Academic Medical Centre Amsterdam.

2.1.1. Adults

Anatomy body donation programme (ABDP): this programme of the University of Amsterdam (UoA) offers persons to donate their body for scientific and educational purposes to the department of anatomy of the UoA. The corpses of all donors routinely undergo total body CT scanning prior to embalming. Of these patients the sex and age are known. The time between demise and arrival in the UoA is also recorded. The cause of death is not known, but corpses can only be accepted by the UoA if the coroner declares it to be a natural cause of death, this therefore excludes cases of drowning.

Safety study (SSt): this is a clinical study in patients who die after an unsuccessful in-hospital resuscitation. These patients undergo total body CT. The next of kin are asked for permission for the scan to be performed. Of these patients the sex and age are known. Cause of death is established, and no cases of drowning were present. The corpses are scanned as soon as possible after demise and as a rule this is done within 4 hours.

2.1.2. Children

NODO study (NODO): between 1–10–2012 and 31–12–2014 children, in the Netherlands, who unexpectedly died of assumed natural causes of death received an extensive work-up to determine the cause of death (the Dutch law dictating this is named Nader Onderzoek DoodsOorzaak). In all cases PMCT was routinely performed. Of these patients the sex and age are known. Cause of death could not be retrieved due to the blinded nature of the study, but there were no cases of drowning in this group as non-natural death was an exclusion criterion for the NODO study.

Forensic studies (FSt): Suspected non-natural paediatric deaths in the Netherlands receive a forensic work-up in the Netherlands Forensic Institute (NFI). Part of the routine work-up in the forensic autopsy is a PMCT. These PMCT's are reported by a paediatric radiologist from the AMC. Of these patients the sex and age are known. Cause of death could not be retrieved due to the blinded nature of the study.

Cases of clear trauma to the face, neck or chest which could lead to fluid in the trachea, e.g. a slicing neck wound to the neck, were excluded from the study. Known cases of drowning were excluded. Also intubated patients, at the time of PMCT, were excluded as the presence of a tube might affect normal post mortem changes.

2.2. CT scanning

The scans for the ABDP and SSt groups were all performed on a Siemens Sensation 64 slice scanner (Siemens medical systems, Erlangen, Germany).

For the NODO study either a Philips Brilliance 16 slice scanner (Philips medical systems, Best, the Netherlands) or a Siemens Sensation 64 slice scanner was used.

For the FSt group the majority of scans were performed on either a Toshiba Aquilon (Toshiba, Tokyo, Japan) or a Siemens Sensation 64 slice scanner. Incidental cases were scanned outside the two NFI related centres, i.e. the AMC and the 'Groene Hart Ziekenhuis' Gouda. Due to the nature of anonymization the type and manufacturer of these scanners could not be retrieved.

Depending on the body size slice thickness ranged from 1 to 4 mm. kV ranged from 100 to 140 and mAs was automatically set.

All scans were stored in a PACS system (Impax v. 6.5.2, Agfa, Mortsel, Belgium).

2.3. Measurements

All PMCT scans were reviewed by three reviewers (AB, SB, RT); radiological technicians in their final year of training and trained in the use of the PACS system. Each reviewer measured one specific item on the PMCT scans, this implies that all items were scored once, no correlation between reviewers was determined. The review process was supervised by a paediatric radiologist (RvR) with extensive experience in PMCT.

2.3.1. Sinus

As the study contains young children the presence of a frontal and/or maxillary sinus was first assessed. If present then on the axial scans visually the maximum area of the sinus was chosen as a measurement point. First the presence of fluid in the sinus was assessed and if present the cross-sectional area of the sinus and the fluid collection was measured using the appropriate tools in the PACS system. By dividing the cross-sectional area of the fluid by the cross-sectional area of the sinus the filling percentage of the sinus was calculated. The cross-sectional measurement automatically also yields the mean Hounsfield unit of the fluid collection.

2.3.2. Trachea and mainstem bronchi

In order to assess the level of measurement oblique coronal reconstructions in the plane of the trachea were generated. Measurements were performed at the following pre-defined levels (Fig. 1A and B):

1. The first slice below the level of the thyroid cartilage (subglottic trachea).
2. Mid-tracheal defined as the midpoint between the measurement 1 and the carina.
3. The last slice above the carina, defined as the last slice where the trachea shows no diversion into the mainstem bronchi.
4. Midpoint of the left mainstem bronchus.
5. Midpoint of the right mainstem bronchus.

If fluid was present in the trachea or mainstem bronchus the cross-sectional area of the trachea or main stem bronchus and of the fluid collection was measured using the appropriate tools in the PACS system. By dividing the cross-sectional area of the fluid by the cross-sectional area of the trachea or mainstem bronchus the percentage of filling of the trachea or mainstem bronchus was calculated (Fig. 2). The cross-sectional measurement automatically also yields the mean Hounsfield unit of the fluid collection. If on visual inspection the fluid collection consisted of a froth (a mixture of air and fluids) then this was noted and the Hounsfield units were not registered.

2.4. Statistical analysis

Data was collected on case report forms and processed using Microsoft Excel. Data analysis was performed using IBM SPSS Statistics v22 (Armonk, NY, USA). Numerical variables are displayed as mean (standard deviation) when distributed normally