**University of
Zurich^{UZH}**

**Zurich Open Repository and
Archive**

University of Zurich
University Library
Strickhofstrasse 39
CH-8057 Zurich
www.zora.uzh.ch

Year: 2021

Prevalence of calcified epiglottitis in postmortem computed tomography. Is there a correlation to failed endotracheal intubation?

Ampanozi, Garyfalia ; Franckenberg, Sabine ; Schweitzer, Wolf ; Thali, Michael J ; Chatzaraki, Vasiliki

Abstract: Objectives: Calcification of the epiglottis is a normal physiological degenerative process, although it can also be a consequence of infection or trauma. There are three possible forensically relevant consequences from epiglottic calcification: misinterpretation as foreign bodies, dysphagia as a major contributing factor to aspiration, and association with difficult intubation or a misplaced ventilation tube. It is the aim of this study (I) to inquire about the prevalence of epiglottic calcification in postmortem CT in general and (II) to investigate whether calcification of the epiglottis is linked to a higher incidence of failed endotracheal intubation. Methods: We retrospectively analysed 2930 consecutive cases in post-mortem CT at the Institute of Forensic Medicine. Results: The prevalence of epiglottic calcification was 4.1%. Higher age and male sex are associated with an increased risk of epiglottic calcification. There was no calcification of the epiglottis in the cases with misplacement of the ventilation tube in the esophagus. Conclusions: To verify the result of our study, that is, the calcification of the epiglottis is not linked to a higher incidence of failed endotracheal intubation, it might be reasonable to repeat this study with a more representative study population. The high interindividual variations of calcified epiglottis could be used for identification.

DOI: <https://doi.org/10.1259/dmfr.20200615>

Posted at the Zurich Open Repository and Archive, University of Zurich

ZORA URL: <https://doi.org/10.5167/uzh-201898>

Journal Article

Published Version

Originally published at:

Ampanozi, Garyfalia; Franckenberg, Sabine; Schweitzer, Wolf; Thali, Michael J; Chatzaraki, Vasiliki (2021). Prevalence of calcified epiglottitis in postmortem computed tomography. Is there a correlation to failed endotracheal intubation? *Dentomaxillofacial Radiology*, 50(5):20200615.

DOI: <https://doi.org/10.1259/dmfr.20200615>

RESEARCH ARTICLE

Prevalence of calcified epiglottis in postmortem computed tomography. Is there a correlation to failed endotracheal intubation?

¹Garyfalia Ampanozi, ^{1,2}Sabine Franckenberg, ¹Wolf Schweitzer, ¹Michael J Thali and ^{1,3}Vasiliki Chatzaraki

¹Department of Forensic Medicine and Imaging, Institute of Forensic Medicine, University of Zurich, Zurich, Switzerland;

²Institute of Diagnostic and Interventional Radiology, University Hospital Zurich, Zurich, Switzerland; ³Department of Radiology, Cantonal Hospital Baden, Baden, Switzerland

Objectives: Calcification of the epiglottis is a normal physiological degenerative process, although it can also be a consequence of infection or trauma. There are three possible forensically relevant consequences from epiglottic calcification: misinterpretation as foreign bodies, dysphagia as a major contributing factor to aspiration, and association with difficult intubation or a misplaced ventilation tube. It is the aim of this study (I) to inquire about the prevalence of epiglottic calcification in postmortem CT in general and (II) to investigate whether calcification of the epiglottis is linked to a higher incidence of failed endotracheal intubation.

Methods: We retrospectively analysed 2930 consecutive cases in postmortem CT at the Institute of Forensic Medicine.

Results: The prevalence of epiglottic calcification was 4.1%. Higher age and male sex are associated with an increased risk of epiglottic calcification. There was no calcification of the epiglottis in the cases with misplacement of the ventilation tube in the esophagus.

Conclusions: To verify the result of our study, that is, the calcification of the epiglottis is not linked to a higher incidence of failed endotracheal intubation, it might be reasonable to repeat this study with a more representative study population. The high interindividual variations of the calcified epiglottis could be used for identification.

Dentomaxillofacial Radiology (2021) 49, 20200615. doi: [10.1259/dmfr.20200615](https://doi.org/10.1259/dmfr.20200615)

Cite this article as: Ampanozi G, Franckenberg S, Schweitzer W, Thali MJ, Chatzaraki V. Prevalence of calcified epiglottis in postmortem computed tomography. Is there a correlation to failed endotracheal intubation?. *Dentomaxillofac Radiol* 2021; 49: 20200615.

Keywords: Calcification of epiglottis; calcified epiglottis; postmortem computed tomography; virtopsy; failed endotracheal intubation

Introduction

Calcification of the epiglottis is rare, although it is a normal physiological process for hyaline cartilage to degenerate and calcify with age.¹⁻⁶ In a postmortem examination of 150 cases, no calcification of the epiglottis was found up to the age of 55 in either sex.⁷ Furthermore, more recent research with postmortem microscopic analysis of the epiglottis in nearly 300

adults showed an increasing volume of calcification with age in both sexes and a larger volume of calcification in males than in females.⁸

There are several possible forensically relevant aspects of epiglottal calcification. First, epiglottal calcification might be misinterpreted as foreign body in lateral radiographs, which might lead to unnecessary medical interventions.^{2,9,10} It could also lead to wrong conclusions during postmortem CT (PMCT) interpretation by inexperienced readers.

Correspondence to: Sabine Franckenberg, E-mail: sabine.franckenberg@usz.ch

Received 31 December 2020; revised 26 January 2021; accepted 10 February 2021

Second, more calcium is found in the lower part of the epiglottis, where calcification is likely to affect movement.⁸ Since flexibility and elasticity of the epiglottis are important in deglutition, loss of the diverting function of the epiglottis can lead not only to dysphagia but is also considered a major contributing factor to aspiration.^{8,11} Aspiration itself is an important factor leading to pneumonia, with community-acquired pneumonia being a major cause of morbidity and mortality in the elderly.¹²

Third, calcification of the epiglottis might be a reason for difficulties with intubation.⁵ In everyday clinical practice, failed endotracheal intubation is regarded as the principal cause of morbidity and mortality in anesthesiology.¹³ Prior to intubation, the airways are usually evaluated with tests that consider parameters such as body weight, flexibility of the head, neck and jaw (Wilson risk score), visibility of pharyngeal structures (modified Mallampati test) and laryngeal view during direct laryngoscopy (Cormack-Lehane classification).^{14,15} None of these tests are able to capture epiglottic calcification, which can be depicted on imaging only. A meta-analysis showed that the diagnostic accuracy of CT, radiographs and ultrasound was much better than that of the modified Mallampati score for the prediction of a possibly difficult intubation.¹⁴

However, to date, no studies have been conducted to investigate the potential association of calcification of the epiglottis with difficult or failed endotracheal intubations. It is the aim of this study (I) to inquire about the prevalence of epiglottic calcification in PMCT in general and (II) to investigate whether calcification of the epiglottis is linked to a higher incidence of misplaced endotracheal intubation in the oesophagus.

Methods and materials

Subjects

We retrospectively searched the database at the Institute of Forensic Medicine for whole body PMCT scans in the period from January 2014 to September 2018. We obtained 3083 consecutive cases. After application of the exclusion criteria (age under 18 years, advanced

decomposition, trauma to the larynx, prior explantation), the remaining 2930 cases were included. Demographic information was retrieved from the forensic database.

Postmortem computed tomography

PMCT was performed using a 128-slice scanner (SOMATOM Definition Flash, Siemens Healthineers, Erlangen, Germany) on bodies in the supine position using automatic dose modulation (CARE Dose 4D™, Siemens Healthineers, Erlangen, Germany). The imaging parameters were as follows: tube voltage 120 kVp, slice collimation 128 × 0.6 mm. PMCT images of the head and neck were reconstructed with a slice thickness of 1.0 mm and increment of 0.6 mm. PMCT data review was performed on Syngo.by imaging software for multimodality reading (Syngo. Via, Siemens Healthineers, Erlangen, Germany).

Read-out

In a first evaluation by a resident with 2 years of experience in forensic imaging, all cases were divided into two groups according to the presence or absence of epiglottic calcification regardless of calcification extent. In addition, the presence of a ventilation tube and its correct position in the trachea or malposition in the oesophagus were evaluated.

In a second evaluation phase, two forensic pathologists with over 10 years of experience in forensic imaging visually categorized the calcification grade of each epiglottis as mild, moderate and severe (Figure 1) in an oblique coronal maximum intensity projection (MIP) with slice thickness individually adjusted to completely cover each epiglottis. Discrepancies between the readers were discussed and resolved by consensus.

Statistical analysis

All analyses were carried out with R v.3.6.0 (2019-04-26).¹⁶ R Markdown was used for dynamic reporting. The corresponding reporting guideline for observational studies is STROBE.¹⁷

Descriptive statistics included the mean and standard deviation for continuous variables and numbers

Figure 1 Maximum intensity projection (MIP) reconstructions of the larynx in PMCT. Visual categorisation of calcification grade in mild (a), moderate (b) and severe (c).

Table 1 Descriptive table depicting the baseline characteristics of the study population ($N = 2930$)

Gender	
Male – N (%)	1971 (67.3)
Female – N (%)	959 (32.7)
Mean age in years (SD)	58.4 (18.3)
Epiglottis calcification	
No calcification – N (%)	2809 (95.9)
Mild calcification – N (%)	50 (1.7)
Moderate calcification – N (%)	59 (2.0)
severe calcification – N (%)	12 (0.4)
Intubation – N (%)	
No – N (%)	2565 (87.5)
Yes – N (%)	365 (12.5)

and percentages of total for categorical and ordinal variables.

The prevalence and 95% confidence interval of cases with epiglottic calcification was estimated using the Wilson method.¹⁸ In this study, the prevalence of the outcomes of interest was low; therefore, an appropriate method for estimating the prevalence and its confidence interval had to be used.

Furthermore, to identify an association between age and sex and the odds of epiglottic calcification, simple and multiple logistic regression models were fitted. To address the level of calcification, graphical display with boxplots was used for association with age. A chi-square test was used to assess the association with gender.

To assess the level of agreement between the two raters, for those cases where double ratings were performed, weighted Cohen's κ was calculated, with squared weights.¹⁹

Results

The study group consisted of 1971 males (67.2%) and 959 females (32.7%), and the age range was 18–99 years (mean 58.4 years). Descriptive statistics are shown in [Tables 1 and 2](#).

The prevalence of epiglottic calcification was 4.1%, with a 95% confidence interval (CI) from 3.5 to 4.9%. Of all cases included in the study, 12.5% were intubated (95% CI: 11.3–13.7%). Within the intubated group, the proportion of cases with incorrectly placed tubes in the oesophagus was 1.6% (95% CI: 0.7–3.7%).

Table 2 Relationship between calcification grade and gender. There is a strong evidence for an association between gender and calcification grade ($p < 0.001$)

	Calcification Grade				Total –N (%)
	No	Mild	Moderate	Severe	
Female – N (%)	940 (98.0)	11 (1.1)	6 (0.6)	2 (0.2)	959 (100 %)
Male – N (%)	1869 (94.8)	39 (2.0)	53 (2.7)	10 (0.5)	1971 (100 %)
Total – N (%)	2809 (95.9)	50 (1.7)	59 (2.0)	12 (0.4)	2930 (100 %)

Table 3 Logistic models for prediction of epiglottic calcification

	Univariate analysis			Multivariable analysis		
	OR	95% CI	p	OR	95% CI	p
Age	1.08	1.07–1.1	<0.001	1.09	1.08–1.11	<0.001
Female sex	0.37	0.22–0.59	<0.001	0.21	0.12–0.34	<0.001

For males, 1869 (94.8%) showed no epiglottis calcification, and 102 (5.2%) had calcified epiglottis on PMCT. For females, 940 (98%) showed no calcification, and only 19 (2%) showed epiglottis calcification ([Table 2](#)). The mean age of the group with no epiglottis calcifications was 57.6 ± 18.1 years, whereas that of the group with calcified epiglottis was 76.5 ± 12.4 years. Both age and sex were significantly associated with the presence of epiglottic calcification: older age and male sex showed an increased risk for epiglottic calcification compared to younger age and female sex, respectively ([Table 3](#)).

The association of age with epiglottic calcification grade is shown in [Figure 2](#). Due to the relatively small number of cases with severe calcification, no model was explicitly fitted to quantify the association with age. There was an association between male sex and calcification grade (chi-square test: $p < 0.001$).

In the 365 cases with intubation, univariate and multiple logistic regression analyses showed that both age and sex were not associated with an increased risk for malposition of the ventilation tube. The presence of a calcified epiglottis and calcification grade were initially intended to be included in this analysis; however, as there were no cases with epiglottic calcifications among the intubated cases, corresponding odds ratios could not be estimated.

Interrater agreement was fair to good ($\kappa = 0.677$, 95% CI from 0.558 to 0.796) for the cases where consensus was required. As an additional finding during read-out, a high interpersonal variation in the calcification pattern was especially noticeable ([Figure 3](#)).

Discussion

After analysing 2930 postmortem cases, we found a prevalence of 4.1% calcification of the epiglottis. None of the cases with a calcified epiglottis presented with a displaced endotracheal tube.

This study shows a significant increase in epiglottic calcification with increasing age in both sexes and a

Figure 2 MIP reconstructions of the larynx in PMCT. Note the high interpersonal variation of the calcification pattern: linear calcifications (a), diffuse heterogeneous calcifications (b) and extensive planar calcifications (c).

higher prevalence of calcification in males compared to females. Based on a remarkably larger population size, our findings support previous postmortem analysis,⁸ even although our postmortem forensic cases might not be considered representative of the general population. The relatively poor statistical power of the statistic with regard to high degree calcifications and its association with older age may be attributed to the age and sex distribution of our study group of postmortem forensic cases that might not be representative of the general population.

A correlation between calcified epiglottis and incorrectly placed tubes in the esophagus could not be established, as none of the incorrectly intubated cases showed epiglottic calcification. This may be explained by the following four reasons. First, the number of cases with failed intubation in the current study population was small, and a higher case number seems to be necessary to properly address this question. Second, in some of the cases, the endotracheal ventilation tubes had already been removed before forensic investigation, including PMCT. Third, even if the endotracheal tube was assessed as correctly placed on PMCT, there might have been difficulties during insertion; however, related clinical information could not have retrospectively been retrieved in the postmortem setting for the purposes of this study. Fourth, the age group most affected by epiglottis calcification is also the age group

that mostly dies from natural disease, and authorities usually do not request follow-up (PMCT, autopsy) in many of these cases. Even so, knowledge of the diagnostic accuracy of imaging for the prediction of possible difficulties during intubation is considered much better than that of the modified Mallampati score,¹⁴ and given the higher risk of aspiration in patients with calcification of the epiglottis,^{8,11} calcified epiglottis should be emphasized in the clinical radiological report.

During image evaluation, it was incidentally observed that the pattern of epiglottic calcification showed high interindividual variation, which agrees with previous research.⁸ These variations appear to entail a highly individual morphology of epiglottis calcification that might allow for postmortem radiological identification,²⁰ analogous to already established identifications such as visual comparison of antemortem dental radiographs with postmortem dental CT²¹ or ante- and postmortem CT of the paranasal sinuses.²² However, further studies are needed to evaluate this hypothesis.

Reconstructively, calcified epiglottis may signify sequelae of trauma such as swallowing or inhaling corrosive chemicals; it may be a consequence of injury due to a swallowed foreign object. In addition, it may signify a postinfectious state or a systematic disease.⁴

Although the agreement between the two readers was not perfect, it was interpreted as fair to good. The absence of a quantification tool for epiglottic calcification did not allow for a more distinct classification in the three severity grades. However, this is not expected to have significantly influenced the presented results.

Conclusion

In our specific forensic study population, calcification of the epiglottis is not linked to a higher incidence of failed endotracheal intubation. To verify this result, it might be reasonable to repeat the study with a more representative study population.

Figure 3 Boxplots of age versus grade of calcification. The width of the boxplots reflects the number of cases within the distinct grades of epiglottic calcification.

In a forensic context, the high interindividual variations of calcified epiglottis could be used for the identification of unknown decedents.

Acknowledgements

The authors express their gratitude to Emma Louise Kessler, MD, for her generous donation to the Zurich Institute of Forensic Medicine, University of Zurich, Switzerland.

Competing interests

None.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Patient consent

Not applicable (postmortem data).

Ethics

A no-responsibility declaration of the ethics committee has been received (KEK-ZH No: 2015–0686).

Disclosure

The authors declare that they have no conflict of interest.

REFERENCES

- Fernández-Rodríguez A, Benito-Orejas JJ, Jiménez-Pérez AE, Morais-Pérez D. Calcification of the epiglottis. *Acta Otorrinolaringol Esp* 2009; **60**: 215–6. doi: [https://doi.org/10.1016/s0001-6519\(09\)71236-1](https://doi.org/10.1016/s0001-6519(09)71236-1)
- Zoller H, Bowie ER. Foreign bodies of food passages versus calcifications of laryngeal cartilages. *AMA Arch Otolaryngol* 1957; **65**: 474–8. doi: <https://doi.org/10.1001/archotol.1957.03830230050010>
- Mehta AK, Chamyal PC. Unusual ossification of laryngeal cartilages: a case report. *Med J armed forces India*. 52. *India* 1996;: 126. —7p..
- Milroy CM. Ossification of the epiglottis. *J Laryngol Otol* 1992; **106**: 180–2. doi: <https://doi.org/10.1017/S0022215100119036>
- Günbey HP, Günbey E, Sayit AT. A rare cause of abnormal epiglottic mobility and dysphagia: calcification of the epiglottis. *J Craniofac Surg* 2014; **25**: e519–21. doi: <https://doi.org/10.1097/SCS.0000000000001025>
- Ardran GM. Calcification of the epiglottis. *Br J Radiol* 1965; **38**: 592–5. doi: <https://doi.org/10.1259/0007-1285-38-452-592>
- Ajmani ML, Jain SP, Saxena SK. A metrical study of laryngeal cartilages and their ossification. *Anat Anz* 1980; **148**: 42–8.
- Kano M, Shimizu Y, Okayama K, Igari T, Kikuchi M. A morphometric study of age-related changes in adult human epiglottis using quantitative digital analysis of cartilage calcification. *Cells Tissues Organs* 2005; **180**: 126–37. doi: <https://doi.org/10.1159/000086753>
- Jeph S, Aidi M, Shah A, Ly T-T, Bronov O. Calcification of the epiglottis presenting as foreign body sensation in the neck. *J Radiol Case Rep* 2017; **11**: 1–5. doi: <https://doi.org/10.3941/jrcr.v11i6.3093>
- Castán Senar A, Dinu LE, Artigas JM, Larrosa R, Navarro Y, Angulo E. Foreign bodies on lateral neck radiographs in adults: imaging findings and common pitfalls. *Radiographics* 2017; **37**: 323–45. doi: <https://doi.org/10.1148/rg.2017160073>
- Calcaterra TC. Epiglottic reconstruction after supraglottic laryngectomy. *Laryngoscope* 1985; **95**(7 Pt 1): 786–789–9. doi: <https://doi.org/10.1288/00005537-198507000-00007>
- Marik PE, Kaplan D. Aspiration pneumonia and dysphagia in the elderly. *Chest* 2003; **124**: 328–36. doi: <https://doi.org/10.1378/chest.124.1.328>
- Cook TM, MacDougall-Davis SR. Complications and failure of airway management. *Br J Anaesth* 2012; **109** Suppl 1(Suppl 1): i68–85. doi: <https://doi.org/10.1093/bja/aes393>
- Ji C, Ni Q, Chen W. Diagnostic accuracy of radiology (CT, X-ray, US) for predicting difficult intubation in adults: a meta-analysis. *J Clin Anesth* 2018; **45**: 79–87. doi: <https://doi.org/10.1016/j.jclinane.2017.12.023>
- Roth D, Pace NL, Lee A, Hovhannisyan K, Warenits A-M, Arrich J, et al. Airway physical examination tests for detection of difficult airway management in apparently normal adult patients. *Cochrane Database Syst Rev* 2018; **5**: Cd008874. doi: <https://doi.org/10.1002/14651858.CD008874.pub2>
- R Core Team R foundation for statistical computing V, Austria. R: a language and environment for statistical computing..
- von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP, et al. The strengthening the reporting of observational studies in epidemiology (STROBE) statement: guidelines for reporting observational studies. *Lancet* 2007; **370**: 1453–7. doi: [https://doi.org/10.1016/S0140-6736\(07\)61602-X](https://doi.org/10.1016/S0140-6736(07)61602-X)
- Newcombe RG. Two-Sided confidence intervals for the single proportion: comparison of seven methods. *Stat Med* 1998; **17**: 857–72. doi: [https://doi.org/10.1002/\(SICI\)1097-0258\(19980430\)17:8<857::AID-SIM777>3.0.CO;2-E](https://doi.org/10.1002/(SICI)1097-0258(19980430)17:8<857::AID-SIM777>3.0.CO;2-E)
- Cohen J. Weighted kappa: nominal scale agreement with provision for scaled disagreement or partial credit. *Psychol Bull* 1968; **70**: 213–20. doi: <https://doi.org/10.1037/h0026256>
- Christensen AM, Hatch GM. Quantification of radiologic identification (RADid) and the development of a population frequency data Repository. *Journal of Forensic Radiology and Imaging* 2016; **7**: 14–16. doi: <https://doi.org/10.1016/j.jofri.2016.11.001>
- Ruder TD, Thali YA, Rashid SNA, Mund MT, Thali MJ, Hatch GM, et al. Validation of post mortem dental CT for disaster victim identification. *Journal of Forensic Radiology and Imaging* 2016; **5**(2/3): 25–30. doi: <https://doi.org/10.1016/j.jofri.2016.01.006>
- Ruder TD, Kraehenbuehl M, Gotsmy WF, Mathier S, Ebert LC, Thali MJ, et al. Radiologic identification of disaster victims: a simple and reliable method using CT of the paranasal sinuses. *Eur J Radiol* 2012; **81**: e132–8. doi: <https://doi.org/10.1016/j.ejrad.2011.01.060>