Research Square

Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

Risk Factors for Incomplete Thawing in Forensic Postmortem Computed Tomography: A Retrospective Cohort Study

Kai-Han Cheng
National Taiwan University College of Medicine
Fu-Ruei Lai
National Taiwan University College of Medicine
Chin-Chen Chang
macotocc@gmail.com

National Taiwan University College of Medicine
Cho-Hsien Hsu
Ministry of Justice

Research Article

Keywords: Forensic, Incomplete thawing, Postmortem, Computed tomography

Posted Date: August 18th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-10588987/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License.
Read Full License

Additional Declarations: No competing interests reported.

Abstract

Background

Postmortem Computed Tomography (PMCT) is an indispensable noninvasive tool in modern forensic medicine; however, its diagnostic value is often limited in frozen cadavers. Despite the common occurrence of freezing artefacts resulting from incomplete thawing in practice, the associated risk factors have not been systematically quantified. This study aimed to identify and quantify key risk factors for incomplete thawing in forensic PMCT through a retrospective analysis.

Methods

We retrospectively analyzed 351 forensic cases that underwent standardized PMCT scanning at the Forensic Imaging Center of National Taiwan University between March 2023 and February 2024. Cases were classified into an incomplete thawing group (n = 55) and a complete thawing group (n = 296). The associations between incomplete thawing and three variables—season (summer vs. non-summer), age group (children [0–10 years] vs. non-children [> 10 years]), and postmortem interval (≤ 5 days vs. >5 days)—were analyzed using the Chi-squared test.

Results

The overall incidence of incomplete thawing was 15.7%. All three variables were significantly associated with incomplete thawing. The incidence was higher in summer and in children than in non-summer seasons and in non-children, respectively, and markedly increased with a postmortem interval exceeding 5 days.

Conclusion

Summer, pediatric age, and a postmortem interval exceeding 5 days are significant risk factors for incomplete thawing in forensic PMCT. Our findings identify specific high-risk scenarios and underscore residual freezing artifacts as a critical interpretative pitfall that may directly compromise forensic interpretation and medicolegal decision making.

1. Introduction

Postmortem Computed Tomography (PMCT) is a noninvasive imaging technique with an increasingly important role in modern forensic medicine [1, 2]. Compared to traditional autopsy, PMCT allows for the rapid acquisition of whole-body imaging data while preserving corporeal integrity, provides an objective basis for determining the cause of death [3–7], and demonstrates significant advantages in fracture detection, foreign body identification, and gas distribution analysis [8–15].

However, the diagnostic utility of PMCT faces severe challenges when dealing with frozen-preserved bodies. In forensic practice, it is common for bodies to be frozen due to administrative scheduling or preservation requirements. When a body is scanned in an incompletely thawed state, characteristic artifacts caused by ice crystals often appear in the images, such as abnormal density stratification within tissues and obscured organ boundaries [16–18]. These artifacts not only interfere with image interpretation but may also mimic pathological changes such as pulmonary hemorrhage or obscure critical authentic pathologies such as intracranial hemorrhage or aortic dissection, thereby significantly increasing the risk of misdiagnosis. Previous studies indicate that frozen or incompletely thawed bodies exhibit features on PMCT images, such as increased lung density, decreased gray-white matter contrast in the brain, obscured fracture margins, and intravascular gas collections [19–22].

This phenomenon and its potential impact on image interpretation are well recognized in practice; however, current academic literature is confined to case reports or descriptions of freezing artifact imaging features [23]. There remains a paucity of systematic research aimed at identifying "which factors increase the risk of incomplete thawing" and quantifying these risk factors using statistical methods. Consequently, forensic practitioners often rely on subjective experience to judge thawing status when deciding on scanning times, highlighting the urgent need for objective data to establish more reliable assessment criteria and operational procedures.

To address this gap, this study aimed to identify and quantify significant risk factors associated with incomplete thawing in forensic PMCT through a retrospective analysis. We hypothesized that variables such as season, age group, and postmortem interval (PMI) are associated with the incidence of incomplete thawing. We anticipate that the findings of this study will provide an evidence-based foundation for optimizing body preservation strategies and PMCT scanning protocols, thereby enhancing the accuracy and reliability of forensic image interpretations.

2. Materials and Methods

2.1 Study Design and Ethical Considerations

This single-center, retrospective, observational study was conducted to identify risk factors associated with incomplete thawing in forensic cases undergoing PMCT. The study analyzed de-identified postmortem imaging data obtained through formal forensic collaboration and was approved by the Institutional Review Board of National Taiwan University Hospital. All procedures were conducted in accordance with institutional ethical guidelines for the analysis of historical and de-identified data.

2.2 Study Population and Case Selection

We retrospectively reviewed the digital archives of all forensic cases that underwent PMCT scanning at the Forensic Imaging Center of the College of Medicine, National Taiwan University, between March 2023 and February 2024.

The inclusion criterion was any deceased individual who underwent the institution's standardized whole-body, non-contrast PMCT protocol during the study period. Cases were excluded if the imaging data were incomplete or contained severe artifacts unrelated to freezing that precluded a definitive assessment of thawing status. Cases with missing data for a specific predictor variable were retained in the overall cohort but excluded from analyses involving that variable; accordingly, each variable-specific analysis was performed using the available cases.

Following the application of these criteria, a final cohort of 351 cases was included in the analysis. Based on a systematic review of the imaging findings, cases were classified into two distinct cohorts: the "incomplete thawing group" (n=55), defined as cases exhibiting any freezing-related artifacts, and the "complete thawing group" (n=296), which served as the control.

2.3 Data Collection and Variable Definition

Data for all included cases were extracted from the electronic records and radiological reports of the Forensic Imaging Center. All imaging assessments were based on a retrospective review of the PMCT images and original diagnostic reports by a single experienced forensic radiologist (C-C C). The collected variables were defined as follows:

- Primary Outcome: The primary outcome was the incomplete thawing status, which was a binary variable (yes/no). A case was classified as "incomplete thawing" based on the definitive presence of characteristic freezing-induced artifacts on any PMCT image series. These artifacts included, but were not limited to, parenchymal ice crystal structures, abnormal density stratification within organs or fluid collections, and obscured anatomical boundaries. This classification was based on a retrospective review of the images and original diagnostic reports.
- Predictor and Descriptive Variables:

1. Season: Cases were categorized into one of four seasons based on the month of death, following standard meteorological divisions: spring (March–May), summer (June–August), autumn (September–November), and winter (December–February).
2. Age: The age at death was recorded in years. For descriptive purposes, data were stratified into 10-year intervals.
3. PMI: Defined as the time elapsed from the documented time of death to the start of the PMCT scan, recorded in days.
4. Number of Frozen Organs: For cases in the "incomplete thawing group," a descriptive analysis was performed by counting the total number of distinct organs or anatomical regions exhibiting freezing artifacts.

2.4 Imaging Comparison and Autopsy Correlation

A comparative analysis was conducted for a subset of cases within the incomplete thawing group in which either a follow-up, fully thawed PMCT scan, and/or a complete autopsy was performed. The initial,

incompletely thawed PMCT images were systematically compared against the follow-up images or gross pathological findings documented in the autopsy reports. The objective of this comparison was to identify and categorize the diagnostic discrepancies caused by freezing artifacts. These discrepancies included instances in which artifacts mimicked pathological findings (false positives) or where genuine pathologies were obscured or distorted by the artifacts (false negatives).

2.5 Statistical Analysis

Categorical variables were presented as counts (n) and percentages (%). For primary risk factor analysis, key predictor variables were dichotomized based on theoretical mechanisms, data distribution patterns, and clinical relevance, to create focused comparisons.

- Season: Given that summer is a physically distinct season with the highest temperatures, and our data showed a corresponding peak incidence, this variable was grouped into "summer" versus "non-summer" to directly test the hypothesis of high ambient temperature's effect.
- Age: Considering the unique physiological characteristics of children (0–10 years), such as a higher surface-area-to-body-mass ratio, their special status in forensic practice, and the prominent incidence observed in our data, age was dichotomized into children (0–10 years) and non-children (>10 years). Age-specific analyses were performed using 345 cases with available age data.
- PMI: PMI was initially examined descriptively across different time intervals. Inspection of the observed distribution suggested a marked increase in the proportion of incomplete thawing among cases with a PMI >5 days (38.3%) compared with those with a PMI ≤5 days (7.4%). PMI was therefore dichotomized at 5 days for a post hoc exploratory comparison. Because this cutoff was data-driven and not prespecified, the results should be interpreted as hypothesis-generating and require validation in an independent cohort.

Associations between the grouped variables and incomplete thawing status were assessed using Pearson’s chi-square test of independence. For the focused binary comparisons, unadjusted risk ratios (RRs) and their 95% confidence intervals (CIs) were calculated from 2 × 2 contingency tables using the logarithmic method. All tests were two-sided, and a p-value < 0.05 was considered statistically significant. Statistical analyses were performed using IBM SPSS Statistics for Windows, version 25.0 (IBM Corp., Armonk, NY, USA). The study flow and analytical framework are summarized in Fig. 1.

3. Results

3.1 Characteristics of the Study Population

A total of 351 cases that met the inclusion criteria were analyzed in this study. Of these, 55 cases (15.7%) were classified into the "incomplete thawing group," and the remaining 296 cases (84.3%) constituted the "complete thawing group."

3.2 Descriptive Features of the Incomplete Thawing Group

The analysis of the 55 cases with incomplete thawing revealed a specific pattern of organ involvement. Table 1 shows the frequency and proportion of freezing artifacts observed in each organ. The heart was the most frequently affected organ, observed in 78.2% of cases. The gastrointestinal system, including the stomach (67.3%) and intestines (61.8%), was also commonly involved. In contrast, the air-rich lungs were the least frequently affected organs (43.6%).

Table 1. Frequency of Freezing Artifacts by Organ in the Incomplete Thawing Group

Organ	Frequency (n)	Proportion (%)
Heart	43	78.2%
Stomach	37	67.3%
Intestines	34	61.8%
Bladder	34	61.8%
Liver	31	56.4%
Kidneys	31	56.4%
Brain	29	52.7%
Spleen	27	49.1%
Lungs	24	43.6%

3.3 Risk Factor Analysis

3.3.1 Influence of Season

Seasonal variation significantly influenced the incidence of incomplete thawing. As shown in Table 2, the incidence in summer (22.3%) was markedly higher than that in spring (16.9%), autumn (9.2%), and winter (11.9%). A focused comparison between summer and non-summer showed a significant association with incomplete thawing (Pearson chi-square test, $p = 0.019$).

Table 2. Influence of Season on the Incidence of Incomplete Thawing

Distribution by season			
Season	**Total Cases (N)**	**Incomplete Thawing (n)**	**Incidence (%)**
Spring	65	11	16.9%
Summer	112	25	22.3%
Autumn	65	6	9.2%
Winter	109	13	11.9%
Exploratory focused analysis: Summer versus non-summer			
Season	**Incomplete thawing, n/N (%)**	**Unadjusted RR (95% CI)**	***p* value**
Summer	25/112 (22.3%)	1.78 (1.10–2.88)	0.019
Non-summer	30/239 (12.6%)	1.00 (reference)	

RR, risk ratio; CI, confidence interval. Risk ratios are unadjusted. The reference group was assigned an RR of 1.00. *p* values were obtained using Pearson's chi-square test.

3.3.2 Influence of Age

Age was also identified as a significant risk factor, with a pronounced effect in the pediatric population. Table 3 presents the incidence rates across all age strata. The 0–10-year group had an incomplete-thawing proportion of 27.8%. A focused analysis comparing "children (0–10 years)" versus "non-children (>10 years)" robustly confirmed that this disparity was statistically significant ($p = 0.010$), indicating a markedly higher risk in the pediatric group compared to the non-children group (13.7%).

Table 3. Influence of Age on the Incidence of Incomplete Thawing

Distribution by age group			
Age Group (years)	**Total Cases (N)**	**Incomplete Thawing (n)**	**Incidence (%)**
0–10	54	15	27.8%
11–20	9	3	33.3%
21–30	26	2	7.7%
31–40	37	7	18.9%
41–50	48	10	20.8%
51–60	53	5	9.4%
61–70	51	5	9.8%
71–80	51	5	9.8%
81–90	12	1	8.3%
91–100	4	2	50%
Exploratory focused analysis: Children versus non-children			
Age Group	**Incomplete thawing, n/N (%)**	**Unadjusted RR (95% CI)**	***p* value**
Children (0–10 years)	15/54 (27.8%)	2.02 (1.20–3.39)	0.010
Non-Children (>10 years)	40/291 (13.7%)	1.00 (reference)	

Age data were unavailable for six cases; therefore, the age-specific analysis included 345 cases. RR, risk ratio; CI, confidence interval. Risk ratios are unadjusted. The reference group was assigned an RR of 1.00. p values were obtained using Pearson's chi-square test.

3.3.3 Influence of PMI

Among all variables tested, PMI demonstrated the strongest association with incomplete thawing. Table 4A describes the distribution of PMI within the incomplete thawing group, showing a concentration of cases (69.1%) in the 5–10-day interval. More critically, as shown in the focused analysis in Table 4B, a PMI exceeding 5 days had a profound impact on the incidence of incomplete thawing. The incidence rate increased from 7.4% in the short-duration (≤5 days) group to 38.3% in the long-duration (>5 days) group. This dramatic increase was supported by a high degree of statistical significance ($p < 0.0001$), indicating that PMI >5 days showed the largest effect estimate among the examined variables (unadjusted RR, 5.18; 95% CI, 3.13–8.57).

Table 4. Influence of Postmortem Interval (PMI) on the Incidence of Incomplete Thawing

(A) Distribution of PMI among Incomplete Thawing Cases (n=55)

Postmortem Interval (Days)	Frequency (n)	Proportion (%)
1	2	3.6%
2	2	3.6%
3	1	1.8%
4	3	5.5%
5	11	20%
6	8	14.5%
7	2	3.6%
8	6	10.9%
9	1	1.8%
10	10	18.2%
11–20	6	10.9%
21–30	1	1.8%
>30	2	3.6%
Total	55	100.00%

(B) Exploratory focused analysis: PMI >5 days versus PMI ≤5 days

PMI Group	Incomplete thawing, n/N (%)	Unadjusted RR (95% CI)	*p* value
> 5 days	36/94 (38.3%)	5.18 (3.13–8.57)	<0.0001
≤ 5 days	19/257 (7.4%)	1.00 (reference)	

RR, risk ratio; CI, confidence interval. Risk ratios are unadjusted. The reference group was assigned an RR of 1.00. *p* values were obtained using Pearson's chi-square test.

3.4 Freezing-Related Artifacts in Forensic PMCT: Representative Cases

To illustrate the potential effect of incomplete thawing on forensic interpretation, two representative cases with autopsy and/or follow-up correlations were presented. In the first case, PMCT performed in an incompletely thawed state demonstrated extensive ice crystal formations within the pericardial space and adjacent great vessels, which markedly obscured evaluation of the aortic contours and precluded

reliable assessment of a focal rupture as the source of hemopericardium (Fig. 2). Subsequent autopsy revealed a Stanford type A aortic dissection with rupture into the pericardial sac, confirming that a lethal vascular pathology was masked by freezing-related artifacts.

In the second case, PMCT of the frozen brain revealed diffusely decreased parenchymal attenuation with a crescent-shaped hypodense area along the left temporal convexity (Fig. 3). This appearance could be misinterpreted as a subdural hematoma; however, complete thawing and autopsy correlation confirmed the absence of intracranial hemorrhage, indicating that the crescentic lesion represented an ice-related artifact rather than a traumatic pathology. Collectively, these representative cases demonstrate that incomplete thawing may mask lethal pathology and generate false-positive findings, reinforcing the clinical relevance of the high-risk scenarios identified in this study.

4. Discussion

This study aimed to identify significant risk factors for incomplete thawing using forensic PMCT through a retrospective analysis. The results clearly indicate that the summer season, pediatric age (0–10 years), and a PMI > 5 days are significant predictors of incomplete thawing. Among these, prolonged PMI demonstrated the strongest association. This section provides an in-depth interpretation and discussion of our findings.

Season was identified as a significant environmental risk factor. Our study shows that the incidence of incomplete thawing is significantly higher in summer. This suggests that the underlying mechanism is related to uneven thawing caused by ambient temperature. In warmer summer months, the superficial tissues of a cadaver may thaw rapidly upon exposure to warm air, while heat transfer to the deep core organs (such as the heart and liver) is delayed. This can easily lead to a state in which the exterior is thawed, but the interior remains frozen, resulting in severe imaging artifacts during the scan, even if the body feels warm to touch. Although previous studies have described the imaging features of freezing artifacts [18, 22], our study is one of the few to statistically confirm a significant association between season and the risk of incomplete thawing.

In addition to environmental factors, our study found that age was a critical intrinsic risk factor, with children facing a significantly higher risk than non-children. This phenomenon is likely related to the physiological characteristics of children. The higher surface-area-to-body-mass ratio in children often leads to faster and more unstable rates of heat loss and gain than those in adults. This may make their thermal changes during a standardized thawing protocol more difficult to predict and control, thereby increasing the risk of scanning in an incompletely thawed state. This finding is particularly crucial in highly sensitive forensic cases, such as suspected child abuse or sudden infant death, where imaging accuracy is paramount for detecting subtle injuries (such as microfractures or intracranial hemorrhages) that can be obscured by freezing artifacts [23].

Among all the variables tested, PMI exhibited the strongest association. The risk of incomplete thawing was extremely high in samples that were frozen for > 5 days. This is because short-term freezing (such

as 1 or 2 days) only affects superficial tissues, whereas long-term freezing allows the entire body, including large, deep-seated core organs, to reach a more profound and uniform frozen state. This necessitates a longer and more complex thawing process that is difficult to predict, increasing the risk of incomplete thawing. This is consistent with the descriptive statistics of our study: deep, high-mass organs with slow heat transfer, such as the heart and liver, were most frequently affected by freezing artifacts, a situation that was particularly pronounced after prolonged freezing.

Based on our findings, several high-risk scenarios for incomplete thawing of forensic PMCT images can be identified. Cases scanned during the summer season, pediatric cases (0–10 years), and cases with a PMI >5 days are particularly vulnerable. The likelihood of residual freezing artifacts increases substantially when one or more of these factors coexist. In such scenarios, reliance on surface temperature or routine thawing protocols may be insufficient, and the risk of misinterpreting PMCT findings should be explicitly considered during forensic decision-making.

Identifying these risk factors carries significant clinical and practical implications. The results provide a concrete warning for frontline forensic practitioners: when encountering cases with one or more of these risk factors—summer season, pediatric age, or a PMI >5 days—a higher degree of caution regarding the thawing status is warranted, and one should not rely solely on the tactile temperature of the body surface. Furthermore, quantitative data from our study suggest that for these high-risk cases, empirically extending the thawing time or conducting a more thorough physical assessment before scanning should be considered (despite the limited surface temperature). However, the most critical recommendation is that, to fundamentally avoid the interference of imaging artifacts and ensure the quality of medicolegal investigations, refrigeration should be prioritized over freezing as a preservation method for deceased individuals who are expected to undergo PMCT.

4.1 Limitations

Several methodological considerations should be taken into account when interpreting these findings. The study's retrospective design is a primary limitation, as it relies on previously recorded data, which introduces the potential risk of incomplete records or information bias. Our analysis did not account for several potential confounding variables that could have influenced the thawing process. For instance, factors such as body mass index, cause of death (such as exsanguination or shock), clothing on the body, and the time interval between death and placement in cold storage were not included in the analysis due to difficulties in standardization or unavailability of existing records. These factors may have affected the results.

Among the examined variables, PMI showed the strongest association with incomplete thawing. Cases with a PMI >5 days had a substantially higher proportion of incomplete thawing than those with a PMI ≤5 days. A longer PMI may allow more prolonged cold storage and deeper freezing of internal organs; however, the actual duration of freezing was unavailable in this study. This potential mechanism should therefore be interpreted cautiously. The 5-day PMI cutoff was selected post hoc after inspection of the observed data and therefore requires validation in an independent cohort.

Furthermore, the assessment of diagnostic discrepancies was limited because the representative cases used to illustrate these challenges were drawn from a subset of cases that underwent either follow-up scans or complete autopsies. A direct one-to-one comparison with autopsy findings or fully thawed images was not possible for all 55 cases in the incompletely thawed group. In addition, a time lag of several hours existed between the PMCT scan and autopsy, during which the body continued to thaw naturally, potentially creating discrepancies between the imaging and autopsy states. Therefore, while the case studies demonstrated the potential risks of artifacts, this study could not systematically quantify the exact incidence of such diagnostic discrepancies across the entire cohort of incompletely thawed cases.

5. Conclusion

Our study demonstrates that summer season, pediatric age (0–10 years), and a PMI > 5 days are significant risk factors for incomplete thawing in forensic postmortem CT. These findings identify specific high-risk scenarios in which residual freezing artifacts are more likely to occur, underscoring the inherent difficulty in reliably assessing the thawing status prior to imaging. Notably, incomplete thawing should be recognized not merely as a technical imaging limitation but as a substantial risk to forensic interpretation and decision-making, as freezing-related artifacts may obscure genuine pathological findings or mimic traumatic lesions, thereby increasing the risk of misclassification of the cause and manner of death. To mitigate this risk and ensure the accuracy of medicolegal investigations, refrigeration rather than freezing should be prioritized as the standard preservation method for deceased individuals expected to undergo PMCT. Collectively, these results provide an evidence-based foundation for optimizing body-preservation strategies and enhancing the reliability and forensic value of PMCT in routine practice.

Declarations

Acknowledgement

Nil

Authors' contributions

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Kai-Han Cheng, Fu-Ruei Lai and Chin-Chen Chang. The first draft of the manuscript was written by Kai-Han Cheng and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Clinical trial number: not applicable

Funding

This study received funding from National Science and Technology Council, Taiwan (NSTC 115-2320-B-002-054-MY3)

Competing interest

The authors have no relevant financial or non-financial interests to disclose.

Declaration of generative AI and AI-assisted technologies in the manuscript preparation process

During the preparation of this manuscript, the authors used Google Gemini for English-language editing. The authors subsequently reviewed and edited the content and take full responsibility for the final manuscript.

Data availability

The data is not publicly available due to ethical and legal restrictions but is available from the corresponding author upon reasonable request.

Research involving Human Participants

This retrospective study was approved by the Institutional Review Board of National Taiwan University Hospital and analyzed de-identified postmortem imaging data obtained through formal forensic collaboration. All procedures complied with applicable ethical guidelines and the Declaration of Helsinki.

Informed consent

Informed consent was waived due to the retrospective design, use of de-identified data, and involvement of deceased individuals.

Consent to publish

Not applicable.

References

1. Davendralingam N, Brookes A-L, Shah MA, Shelmerdine SC (2024) Post-mortem CT service structures in non-suspicious death investigations. BJR|Open 6: tzae036. doi: 10.1093/bjro/tzae036
2. Solomon N, Elifritz J, Adolphi NL et al (2025) Postmortem CT: Applications in Clinical and Forensic Medicine. RadioGraphics 45: e240192. doi: 10.1148/rg.240192
3. Lathrop S, Wiest P, Andrews S et al (2023) Can computed tomography replace or supplement autopsy? Journal of Forensic Sciences 68: 524-35. doi: 10.1111/1556-4029.15217

4. Andrews SW (2016) Postmortem Changes as Documented in Postmortem Computed Tomography Scans. Acad Forensic Pathol 6: 63-76. doi: 10.23907/2016.006
5. Ampanozi G, Halbheer D, Ebert LC, Thali MJ, Held U (2020) Postmortem imaging findings and cause of death determination compared with autopsy: a systematic review of diagnostic test accuracy and meta-analysis. Int J Legal Med 134: 321-37. doi: 10.1007/s00414-019-02140-y
6. Willaume T, Farrugia A, Kieffer EM et al (2018) The benefits and pitfalls of post-mortem computed tomography in forensic external examination: A retrospective study of 145 cases. Forensic Sci Int 286: 70-80. doi: 10.1016/j.forsciint.2018.02.030
7. Scholing M, Saltzherr TP, Fung Kon Jin PH et al (2009) The value of postmortem computed tomography as an alternative for autopsy in trauma victims: a systematic review. Eur Radiol 19: 2333-41. doi: 10.1007/s00330-009-1440-4
8. Datta A, Galoria D, Dave S, Tiwari P, Shukla S, Patel V (2025) A case report on comparison between PMCT and conventional autopsy approach in traumatic death. SAGE Open Med Case Rep 13: 2050313x251321046. doi: 10.1177/2050313x251321046
9. Oliva A, Grassi S, Zedda M et al (2024) Forensic significance and inferential value of PMCT features in charred bodies: A bicentric study. Forensic Imaging 37: 200590. doi: 10.1016/j.fri.2024.200590
10. Ong HN, Chen IH, Hsieh YH, Hsu CH, Weng TI, Chang CC (2023) Comparison of fatal traumatic medico-legal cases with postmortem computed tomography and autopsy: A pilot study in Taiwan. J Formos Med Assoc 122: 351-4. doi: 10.1016/j.jfma.2022.09.015
11. Chandy PE, Murray N, Khasanova E, Nasir MU, Nicolaou S, Macri F (2020) Postmortem CT in Trauma: An Overview. Can Assoc Radiol J 71: 403-14. doi: 10.1177/0846537120909503
12. Vester MEM, Nolte KB, Hatch GM, Gerrard CY, Stoel RD, van Rijn RR (2020) Postmortem Computed Tomography in Firearm Homicides: A Retrospective Case Series. J Forensic Sci 65: 1568-73. doi: 10.1111/1556-4029.14453
13. Zerbini T, Silva LF, Ferro AC et al (2014) Differences between postmortem computed tomography and conventional autopsy in a stabbing murder case. Clinics (Sao Paulo) 69: 683-7. doi: 10.6061/clinics/2014(10)06
14. Ebert LC, Franckenberg S, Sieberth T et al (2021) A review of visualization techniques of post-mortem computed tomography data for forensic death investigations. Int J Legal Med 135: 1855-67. doi: 10.1007/s00414-021-02581-4
15. Sano R, Takahashi Y, Hayakawa A et al (2018) Use of postmortem computed tomography to retrieve small metal fragments derived from a weapon in the bodies of victims in two homicide cases. Leg Med (Tokyo) 32: 87-9. doi: 10.1016/j.legalmed.2018.03.006
16. Li S, Jin W, He J et al (2024) Imaging Characteristics of Frozen Corpses: An Analysis Based on Postmortem Computed Tomography. J Forensic Sci Med 10(4):274–282. doi: 10.4103/jfsm.jfsm_151_24
17. Sugimoto M, Hyodoh H, Rokukawa M et al (2016) Freezing effect on brain density in postmortem CT. Leg Med (Tokyo) 18: 62-5. doi: 10.1016/j.legalmed.2015.12.007

18. Roe WD, Gartrell BD, Hunter SA (2012) Freezing and thawing of pinniped carcasses results in artefacts that resemble traumatic lesions. Vet J 194: 326-31. doi: 10.1016/j.tvjl.2012.03.028
19. Klop AC, Vester MEM, Colman KL, Ruijter JM, Van Rijn RR, Oostra RJ (2017) The effect of repeated freeze-thaw cycles on human muscle tissue visualized by postmortem computed tomography (PMCT). Clin Anat 30: 799-804. doi: 10.1002/ca.22917
20. Chumakova YV, Dubrova SE, Klevno VA, Sokolova ZY (2022) [Postmortem computed tomography of the frozen corpse]. Sud Med Ekspert 65: 51-5. doi: 10.17116/sudmed20226506151
21. Kawasumi Y, Usui A, Ikeda T, Ishibashi T, Funayama M (2017) Post-mortem computed tomography findings of the frozen brain. Journal of Forensic Radiology and Imaging 10: 37-40. doi: 10.1016/j.jofri.2017.08.001
22. Bolliger SA, Tomasin D, Heimer J, Richter H, Thali MJ, Gascho D (2018) Rapid and reliable detection of previous freezing of cerebral tissue by computed tomography and magnetic resonance imaging. Forensic Sci Med Pathol 14: 85-94. doi: 10.1007/s12024-018-9955-0
23. Giovannini E, Bonasoni MP, Bardaro M et al (2024) Postmortem histological freeze-thaw artifacts: a case report of a frozen infant and literature review. Forensic Sci Med Pathol 20: 1412-9. doi: 10.1007/s12024-023-00752-w

Figures

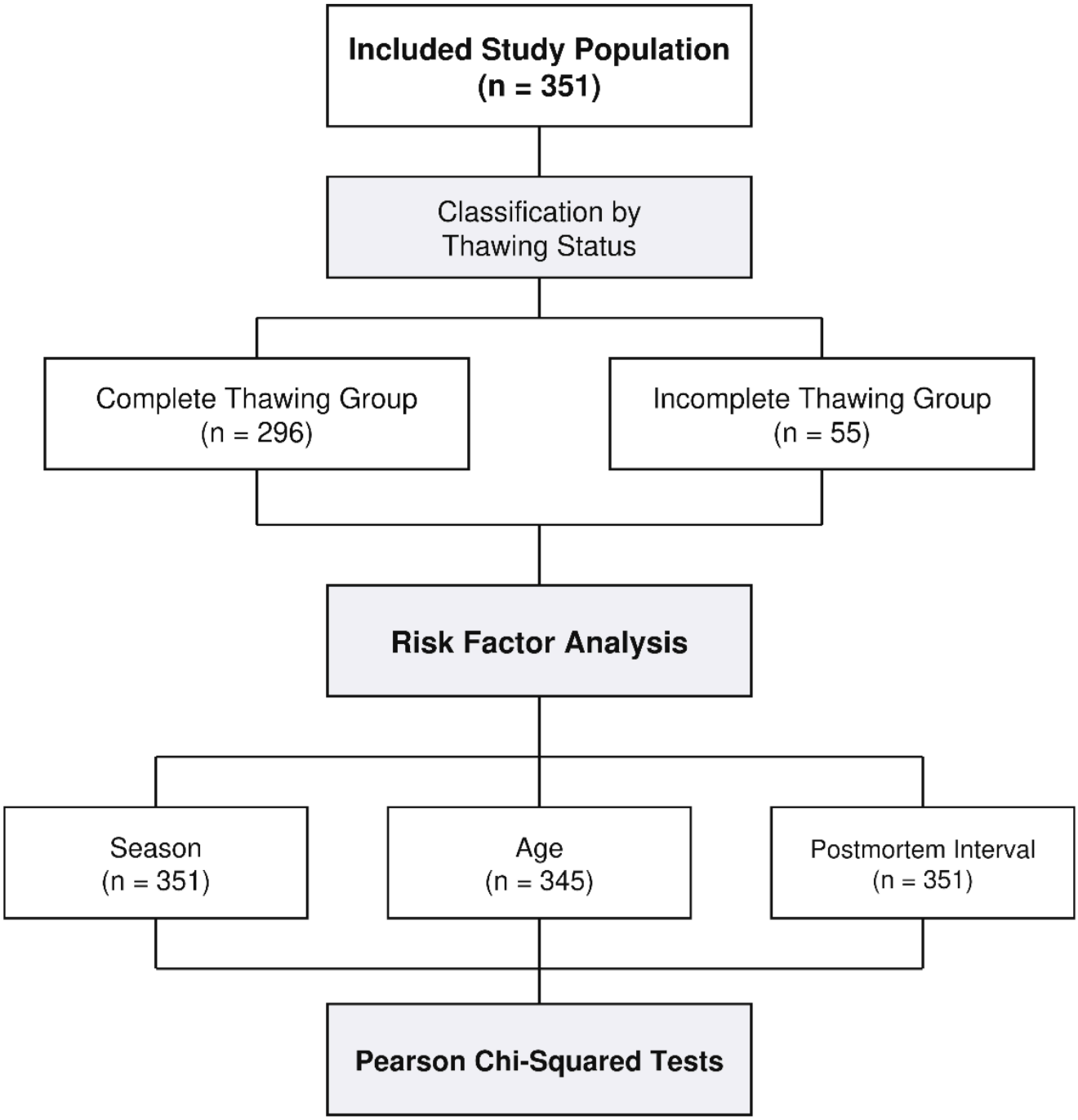

Figure 1

Flow diagram of study population classification and risk factor analysis. A total of 351 forensic PMCT cases were included and classified into the complete thawing group (n = 296) and incomplete thawing group (n = 55). The associations of incomplete thawing with season, age, and postmortem interval were evaluated using chi-squared tests

Abbreviation: PMCT, postmortem computed tomography.

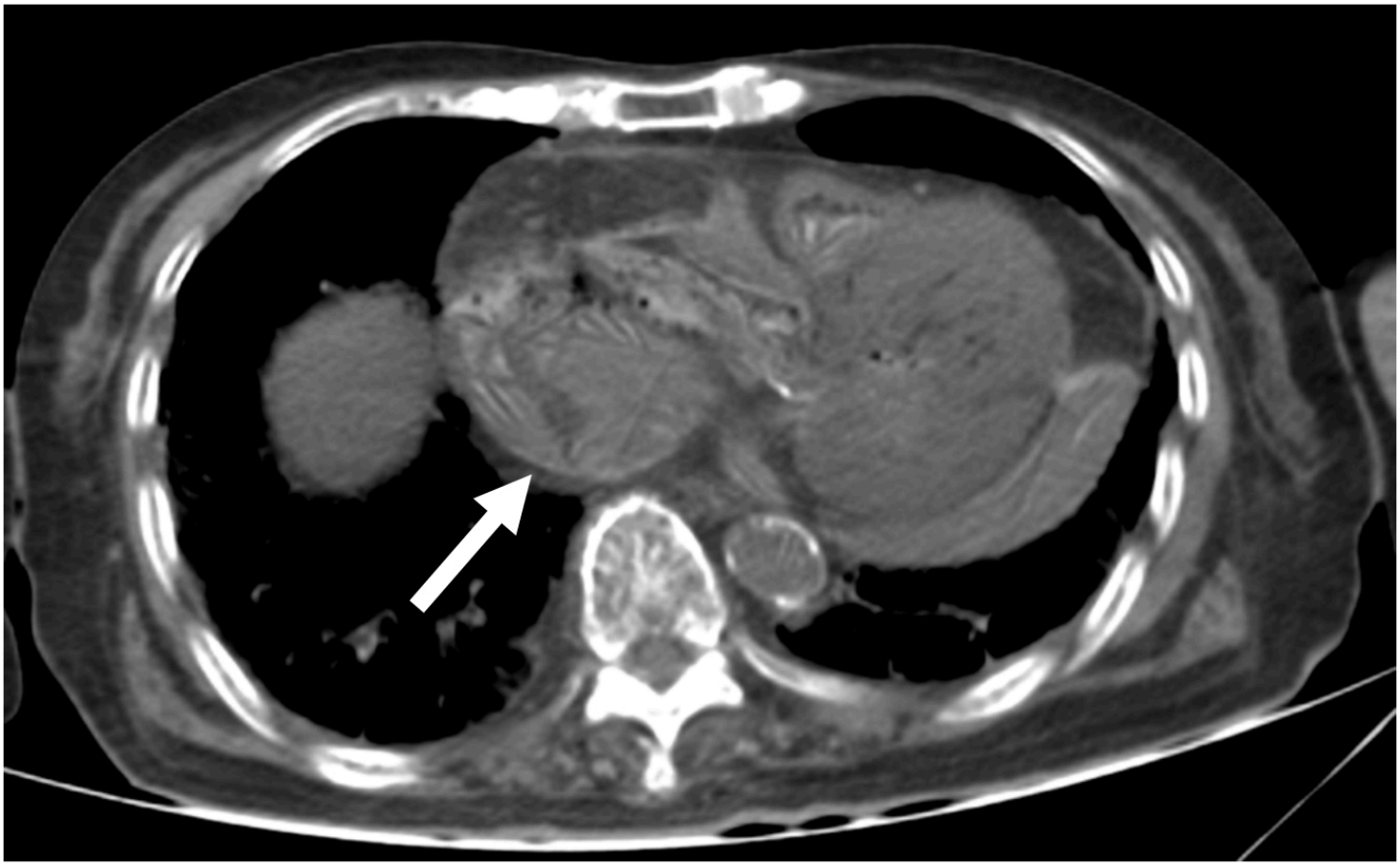

Figure 2

Axial PMCT image obtained in an incompletely thawed body showing extensive ice crystal formations within the pericardial space and adjacent great vessels (arrow), obscuring evaluation of the aortic contour. Autopsy subsequently confirmed a Stanford type A aortic dissection with rupture into the pericardial sac

Abbreviation: PMCT, postmortem computed tomography.

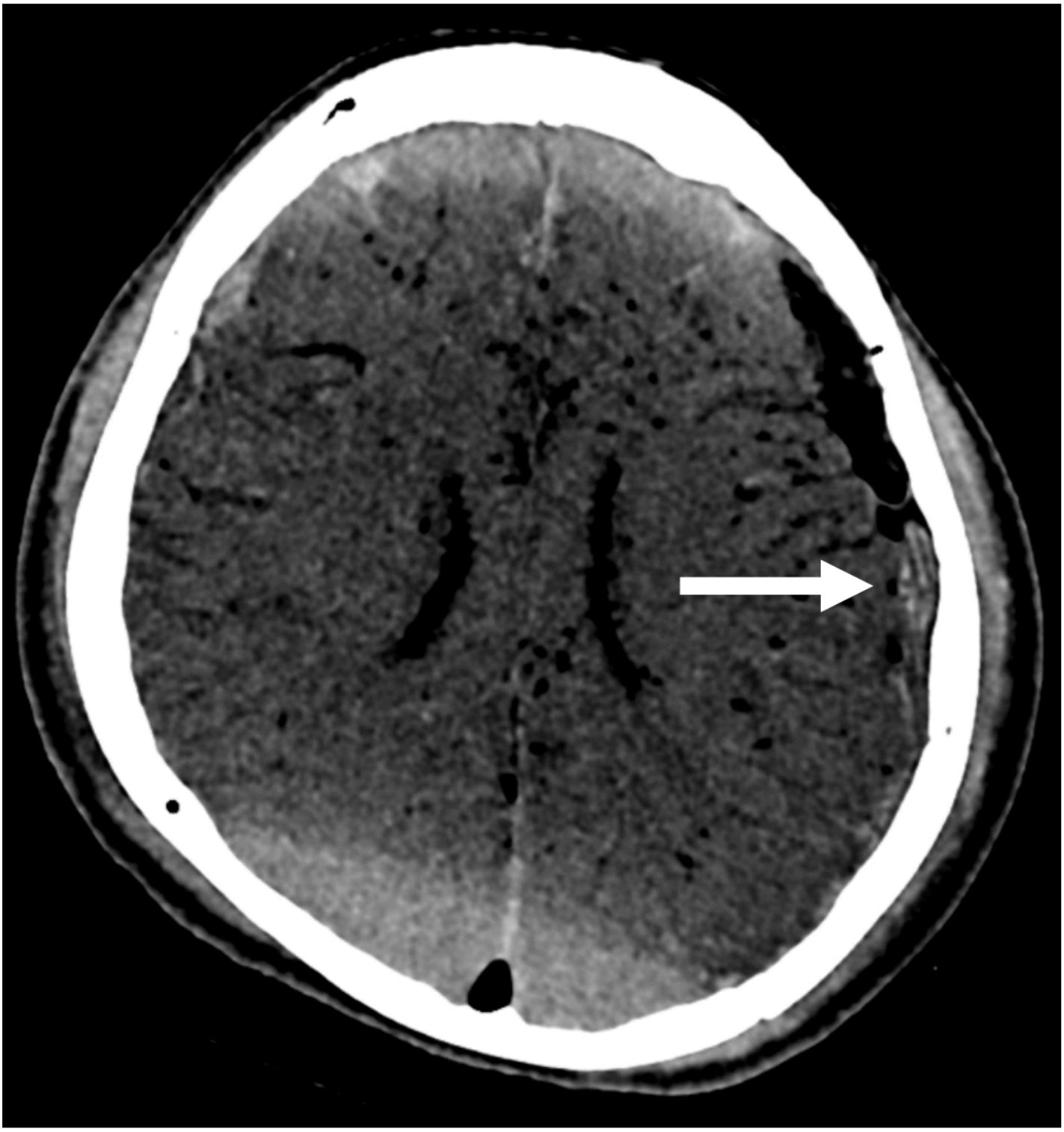

Figure 3

Axial PMCT image of the brain acquired in an incompletely thawed state showing diffusely decreased parenchymal attenuation and a crescent-shaped hypodense area along the left temporal convexity (arrow). This finding mimics a subdural hematoma but was subsequently confirmed to represent a freezing-related artifact after complete thawing and autopsy correlation

Abbreviation: PMCT, postmortem computed tomography.