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INTERVENTIONAL

# Canceled or aborted CT-guided interventions: 13-year clinical experience at a tertiary care center

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## Abstract

**Objective** To determine the frequency and causes of canceled or aborted CT-guided interventions (biopsies, cytological aspirations, hookwire localizations, and catheter drainages), associations with patient and procedural variables, and subsequent management.

**Methods** This study included 3052 consecutive CT-guided interventions (2487 biopsies, 80 cytological aspirations, 223 hookwire localizations, and 262 catheter drainages) performed in a single institution within a 13-year period.

**Results** Fifty-two of 3052 CT-guided interventions were canceled or aborted, corresponding to a frequency of 1.7% (95% confidence interval [CI] 1.3–2.2%). Main causes in order of decreasing frequency included pain, lack of a safe window for intervention, impossibility to position the co-axial or biopsy needle in or near the target, inability to lie still, dyspnea and low oxygen saturation levels, non-discontinuation of anticoagulant therapy, impossibility to aspirate fluid or pus when attempting drainage, and impossibility to advance the drainage catheter in a fluid collection or abscess. On multivariate analysis, only catheter drainages and head-neck interventions were significantly at risk ($p = 0.019$ and $p = 0.004$) to be canceled or aborted, with odds ratios of 2.677 (95% CI 1.178–6.083) and 6.956 (95% CI 1.883–25.691), respectively. Of 52 canceled or aborted CT-guided interventions, 14 (26.9%) were repeated, 19 (36.5%) underwent a different non-CT-guided interventional procedure on the same target, and 19 (36.5%) did not undergo any subsequent intervention.

**Conclusion** The frequency of canceled or aborted CT-guided interventions is low, but is not negligible. Awareness of causes and circumstances under which they are more likely to occur may reduce the number of canceled or aborted CT-guided interventions.

**Key Points**

- *Approximately 1.7% of CT-guided interventions, for which the patient physically shows up at the CT room and which are considered useful by the radiologist, are eventually canceled or aborted.*
- *Main causes (of which some may be prevented) are pain, lack of a safe window, impossibility to position the co-axial or biopsy needle, inability to lie still, dyspnea, non-discontinuation of anticoagulant therapy, and impossibility to aspirate liquid or advance the catheter when attempting drainage.*
- *CT-guided catheter drainages and head-neck interventions are particularly prone to being canceled or aborted.*

**Keywords** Biopsy · Cytology · Drainage · Interventional radiology · Multidetector computed tomography

**Abbreviations**

CI Confidence interval
CT Computed tomography

## Introduction

Computed tomography (CT)–guided diagnostic and therapeutic interventions such as biopsy, cytological aspiration, hookwire localization, and catheter drainage have become widely disseminated throughout the world and are performed on a routine clinical basis [1, 2]. CT guidance allows targeting both soft tissues and bones in various anatomic areas and has the advantage of being less invasive and costly than surgical approaches [2]. Nevertheless, CT-guided interventions involve the use of potentially harmful ionizing radiation [3]

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(although new CT-scanner generations involve markedly lower radiation doses [4]), are still invasive with associated risk of complications [5], and involve costs.

In our experience, most procedures performed under CT guidance are successful. For example, tissue or cells can be obtained during a biopsy or cytological aspiration procedure, a hookwire can be placed in or near the lesion of interest, or a drainage catheter can be positioned in a fluid collection or abscess. However, in some instances, a CT-guided intervention is canceled (i.e., scheduled, but abandoned before even started) or aborted (i.e., started, but terminated before achieving its intended purpose). This can be regarded as an unnecessary burden to the patient, and it has a negative impact on healthcare resource utilization and costs. Currently, there is a lack of literature on the frequency and causes of canceled or aborted CT-guided interventions. Such data may yield valuable insight into whether this is a relevant or negligible clinical problem and may provide clues on how to prevent or minimize CT-guided interventions being canceled or aborted. Also, it is unclear what happens to patients after a CT-guided procedure that is unsuccessful at first attempt.

The purpose of this study was therefore to determine the frequency and causes of canceled or aborted CT-guided interventions (biopsy, cytological aspiration, hookwire localization, or catheter drainage), associations with patient and procedural variables, and subsequent management.

## Materials and methods

### Study design

This retrospective study was approved by the local institutional review board (IRB number: 201800105), and the requirement for informed consent was waived. All patients who were scheduled and physically showed up to undergo a biopsy, cytological aspiration, hookwire localization, or catheter drainage under CT guidance at the department of radiology of a single tertiary care university medical center within a 13-year period (January 2005 to December 2017) were eligible for inclusion. Patients who underwent another type of intervention under CT guidance such as radiofrequency ablation, nerve block, joint injection, or cerebrospinal fluid aspiration were not included. Patients who did not show up at the CT room and patients in whom the aim of the intervention was considered not useful by the attending radiologist (due to the absence of a clear target for intervention or lack of a clinical benefit of the intervention to the patient based on the preprocedural planning CT [e.g., decrease in size of lesions or fluid collections that were to be targeted by the intervention]) were also excluded.

### CT-guided interventions

All CT-guided biopsies, cytological aspirations, hookwire localizations, and catheter drainages were performed with the use of a 16- or 64-slice CT system (Siemens SOMATOM Sensation 16 until December 2014 and Siemens SOMATOM Definition 64 after December 2014). Interventional procedures were performed by or under the supervision of different radiologists, both with and without subspecialization in interventional radiology. Patient positioning (head or feet first, supine, prone, sideways) on the CT table depended on the location of the target, patient's condition, and radiologist's preference. A radiopaque localization grid was placed on the skin of the patient covering the target area, after which a planning CT was done (either contrast-enhanced or unenhanced, depending on the region of interest and radiologist's preference). After skin disinfection and placement of a sterile fenestrated drape, local anesthesia (lidocaine 1%) was injected. Local anesthesia was injected up to the target, if technically and safely possible (e.g., for bone lesions, only the periosteum was anesthetized, and for lung lesions, anesthesia was only injected superficially to the parietal pleura). Subsequently, a small skin incision was made, and a co-axial and/or biopsy needle was inserted and advanced to the target under CT guidance. After adequate positioning, histological biopsy, cytological aspiration, hookwire deployment, or catheter drainage placement (Seldinger technique) was done. All procedures were performed under sterile conditions.

### Canceled or aborted CT-guided interventions

Canceled interventions were defined as those in which the patient showed up at the CT room, but any other step of the actual intervention (planning CT, local anesthesia and skin incision, advancement of interventional devices into the patient, and either biopsy, cytological aspiration, hookwire localization, or catheter drainage) could not be carried out, due to whatsoever reason. Aborted interventions were defined as those in which the patient showed up at the CT room and the actual intervention had started (i.e., at least planning CT was done), but had to be prematurely terminated before either local anesthesia and skin incision, biopsy, cytological aspiration, hookwire localization, or catheter drainage could take place, due to whatever reason. Aborted interventions were subdivided into the following: (a) abortion after planning CT, (b) abortion after planning CT and local anesthesia, and (c) abortion after planning CT, local anesthesia, and introduction of interventional devices into the patient.

### Subsequent management after canceled or aborted CT-guided interventions

In patients whose CT-guided intervention was canceled or aborted, it was determined if the same intervention was repeated at a different time point, if a different non-CT-guided interventional procedure was performed on the same target, or if no subsequent intervention was performed on the same target.

### Statistical analysis

The frequency of canceled or aborted CT-guided interventions was calculated, along with 95% confidence intervals (CIs). Differences in frequencies among each of the 13 individual years during which the interventions were performed were assessed with a chi-square test. Causes of canceled or aborted CT-guided interventions were descriptively analyzed. Logistic regression analyses were performed to determine the association of patient age and gender, year in which the intervention was performed, type of intervention (biopsy, cytological aspiration, hookwire localization, or catheter drainage), body region (15 different body regions as displayed in Table 1), type of target tissue (soft tissue or bone), and type of radiologist performing the intervention (radiologist with or radiologist without subspecialization in interventional radiology), with the occurrence of canceled or aborted interventions. Variables that were significant on univariate analysis were entered into multivariate analysis. Finally, percentages of repeated interventions, different interventions, or subsequent non-interventions were calculated. All $p$ values less than 0.05 were considered statistically significant. Statistical analyses were executed using MedCalc version 17.2 Software (MedCalc).

**Table 1** Body regions that were targeted by 3052 CT-guided interventions

| Body region | No. |
|---|---|
| Lung | 835 |
| Extremities | 686 |
| Abdomen | 477 |
| Spine | 393 |
| Pelvis | 352 |
| Sacrum | 104 |
| Mediastinum | 63 |
| Non-osseous chest wall | 36 |
| Rib | 35 |
| Head-neck | 31 |
| Sternum | 27 |
| Heart-pericardium | 6 |
| Abdominal wall | 2 |
| Axilla | 1 |
| Breast | 1 |
| Combinations | 3[a] |

[a] During one intervention session, both the abdomen and pelvis were targeted in one patient, both the abdomen and pelvis were targeted in another patient, and both the spine and extremities were targeted in yet another patient

## Results

### CT-guided interventions and patients

A total of 3081 CT-guided interventions (biopsies, cytological aspirations, hookwire localizations, and catheter drainages) were scheduled between January 2005 and December 2017. Of these 3081 interventions, 1 was excluded because the patient did not show up at the CT room without any specified reason, and 28 were excluded because they were considered not useful by the attending radiologist due to the absence of a clear target for intervention ($n = 8$) or lack of a clinical benefit of the intervention to the patient based on the preprocedural planning CT ($n = 20$). The remaining 3052 interventions that were finally included in this study consisted of 2487 biopsies, 80 cytological aspirations, 223 hookwire localizations (lung: $n = 222$; breast: $n = 1$), and 262 catheter drainages. These interventions were performed in 2786 unique patients (221, 18, and 3 patients underwent 2, 3, and 4 separate interventions, respectively), of whom 1495 were male and 1291 female, with a median age at the time of intervention of 60 years (range 0–92 years; interquartile range 46–69 years). The primary target of the intervention was soft tissue in 1639 patients, bone in 1412 patients, and both soft tissue and bone in 1 patient (2 different targets during 1 intervention session). Of 3052 interventions, 312 were performed by radiologists with subspecialization in interventional radiology.

### Frequency and causes of canceled or aborted CT-guided interventions

Fifty-two of 3052 CT-guided interventions were canceled or aborted, corresponding to a frequency of 1.7% (95% CI: 1.3–2.2%). The frequencies among each of the 13 individual years during which the interventions were performed were not significantly different ($p = 0.496$). The 52 canceled or aborted interventions consisted of 39 biopsies, 12 catheter drainages, and 1 wire localization. Of these 52 interventions, 9 interventions were canceled, while 43 interventions were aborted. Of the 43 aborted interventions, 13 were aborted after planning CT, 2 were aborted after planning CT and local anesthesia, and 28 were aborted after planning CT, local anesthesia, and introduction of interventional devices into the patient. Table 2 lists the causes of the canceled or aborted interventions. Main causes in order of decreasing frequency included pain, lack of a safe

**Table 2** Causes of canceled and aborted CT-guided interventions

| Canceled interventions ($n = 9$) | Aborted interventions ($n = 43$) | | |
|---|---|---|---|
| | After planning CT ($n = 13$) | After planning CT and local anesthesia ($n = 2$) | After planning CT, local anesthesia, and introduction of interventional devices into the patient ($n = 28$) |
| Inability to lie still due to pain ($n = 2$) | No safe window ($n = 9$) | Too much pain ($n = 1$) | Too much pain ($n = 9$) |
| Non-discontinuation of anticoagulant therapy ($n = 2$) | Inability to lie still any longer ($n = 3$) | Iatrogenic pneumothorax ($n = 1$) | Impossibility to position the co-axial or biopsy needle in or near the target ($n = 10$)[a] |
| Inability to lie still due to pain and non-discontinuation of anticoagulant therapy ($n = 1$) | Oxygen saturation drop ($n = 1$) | | Impossibility to aspirate fluid or pus ($n = 3$)[b] |
| Dyspnea and low oxygen saturation ($n = 1$) | | | Impossibility to advance drainage catheter into a fluid collection or abscess ($n = 3$)[b] |
| Inability to lie still due to pain and dyspnea ($n = 1$) | | | Inability to lie still ($n = 2$) |
| No safe window ($n = 1$) | | | Impossibility to position the co-axial or biopsy needle in or near the target, pain, and dyspnea ($n = 1$) |
| Intravenous contrast administration (considered necessary for biopsy) not possible due to poor renal function ($n = 1$) | | | |

[a] Of which 5 due to iatrogenic pneumothorax

[b] Drainage

window for intervention, impossibility to position the co-axial or biopsy needle in or near the target (of which half were due to iatrogenic pneumothorax), inability to lie still, dyspnea and low oxygen saturation levels, non-discontinuation of anticoagulant therapy, impossibility to aspirate fluid or pus when attempting drainage, and impossibility to advance the drainage catheter into a fluid collection or abscess. Representative examples are shown in Figs. 1 and 2.

### Associations of patient and procedural variables with canceled or aborted CT-guided interventions

On univariate analysis, type of intervention (catheter drainage) and body region (abdomen and head-neck) were significantly associated with canceled or aborted CT-guided interventions, while other variables were not. On multivariate analysis, only catheter drainages and head-neck interventions (biopsies) were significantly at risk ($p = 0.019$ and $p = 0.004$) to be canceled or aborted, with odds ratios of 2.677 (95% CI 1.178–6.083) and 6.956 (95% CI 1.883–25.691), respectively. All logistic regression analyses are displayed in Table 3.

### Subsequent management after canceled or aborted CT-guided interventions

Of 52 canceled or aborted CT-guided interventions, 14 (26.9%) were repeated (of which 12 were technically successful and 2 were once more aborted), 19 (36.5%) underwent a different non-CT-guided interventional procedure on the same target (surgical [$n = 13$], ultrasound-guided [$n = 3$], fluoroscopic under full anesthesia [$n = 2$], and bronchoscopic [$n = 1$]), and 19 (36.5%) did not undergo any subsequent intervention.

## Discussion

The results of this study show that approximately 1 out of 59 (1.7%) CT-guided interventions (biopsies, cytological aspirations, hookwire localizations, and catheter drainages combined), for which the patient physically shows up at the CT room and which are considered useful by the attending radiologist, is eventually canceled or aborted. Although this frequency is relatively low, efforts should be made to prevent or minimize this type of waste of time and resources and the associated burden and potential side effects of the intervention to the patient.

Preprocedural pain and inability of the patient to lie still, dyspnea and low oxygen saturation levels, and non-discontinuation of anticoagulant therapy may be recognized before the patient arrives at the CT room, and these should routinely be checked for. However, some causes of CT-guided interventions that are canceled or aborted cannot be anticipated. For example, intolerable pain when advancing interventional devices to the target despite the use of local anesthesia

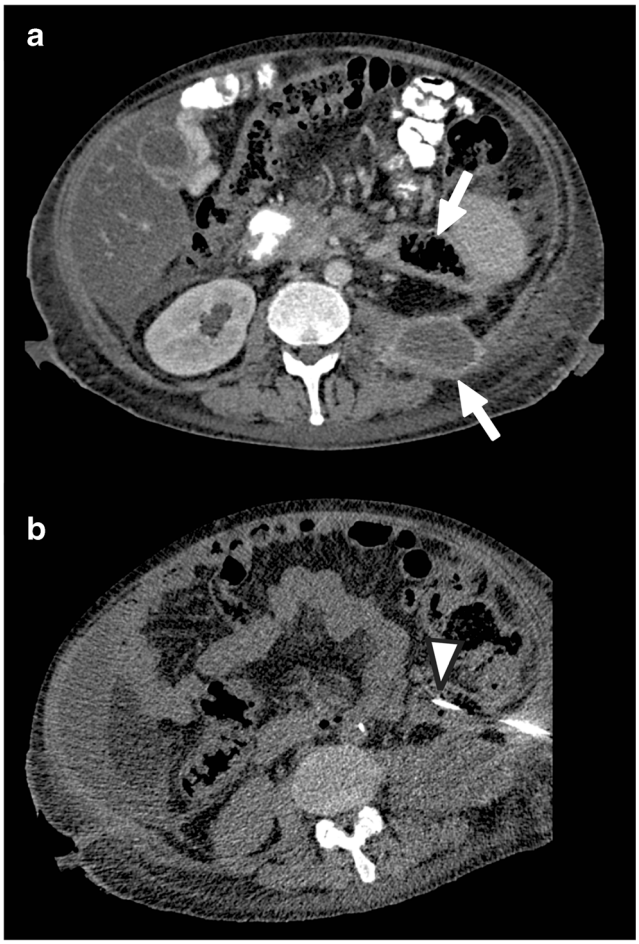


**Fig. 1** Aborted CT-guided intervention in a 49-year-old man with necrotizing pancreatitis who was referred for drainage of a peripancreatic collection. Diagnostic CT scan shows parts of the peripancreatic collection (filled with fluid and air) in the left retroperitoneal space that are communicating with each other (**a**, arrows). After planning CT, local anesthesia, and introduction of a guidewire in the peripancreatic collection (**b**, arrowhead), it was attempted to advance the drainage catheter. However, this was too painful for the patient, and the procedure had to be aborted. CT-guided drainage was successfully repeated under conscious sedation 10 days later

and impossibility to advance a drainage catheter into a fluid collection or abscess only come to light when actually performing the procedure. Other causes are ambiguous as to whether they can be prevented or not, and these include the lack of a safe window, impossibility to position the co-axial or biopsy needle in or near the target, and impossibility to aspirate fluid or pus when attempting drainage. These issues may be anticipated based on previous cross-sectional imaging examinations, but it may well be that they are only recognized after preprocedural planning CT or advancing interventional devices into the patient.

CT-guided catheter drainages and procedures in the head-neck area proved to be particularly prone to being canceled or aborted. This may in part be explained by the fact that catheter drainages generally consist of more procedural steps and may therefore take more time and consequently be experienced as more painful than biopsies, cytological aspirations, and hookwire localizations. It may also be explained by the larger diameter of the inserted devices used for drainages and also because local anesthesia is less efficient in infected structures. Painful and extended intervention time will decrease patients' tolerability. This issue played a role in half of discontinued drainages. Other reasons for aborted drainages were the impossibility to aspirate fluid or pus and impossibility to advance the drainage catheter into the fluid collection or abscess. All discontinued head-neck interventions were due to the lack of a safe window for biopsy, which is probably related to the high density of vital small organs in this body region. These findings may be of value for radiologists to consider when CT-guided drainages or head-neck interventions are requested by referring physicians and for patient counseling. Nevertheless, it should be noted that CT-guided head-neck interventions only represented a very small portion of all CT-guided interventions (1%) and that they may be less of a problem from a relative standpoint.

Only 26.9% of canceled or aborted CT-guided interventions were repeated (of which most were technically successful). This may be due to reluctance of the referring physician or patient to repeat the CT-guided intervention, changes in the patient's disease or condition that decreased or nullified the clinical utility of the CT-guided intervention, or the availability of another target for intervention that allows achieving the same purpose (e.g., tissue biopsy of another lesion in the body to confirm metastatic disease). The remainder either underwent a different intervention (usually surgical) or did not undergo any subsequent intervention at all. Further research is necessary to determine which subsequent interventions or non-interventions are most (cost-)effective after a CT-guided intervention that is canceled or aborted at first attempt.

The proportion of technically successful CT-guided interventions may be regarded as a quality indicator. It is unknown if the frequency of canceled or aborted CT-guided interventions that was found in the present study (1.7%) is low, average, or high, because data on this topic with previously defined patient inclusion criteria are completely lacking. Nevertheless, this frequency was constant over the consecutive 13-year period of this study (a chi-square test did not reveal any significant difference [$p = 0.496$] among the 13 individual years). Therefore, it may be regarded as representative for a tertiary care university medical center and may be used for both internal and external benchmarking.

This study had several limitations. First, this study was performed in a tertiary care university medical center, and it is unknown if its findings are also applicable to non-academic

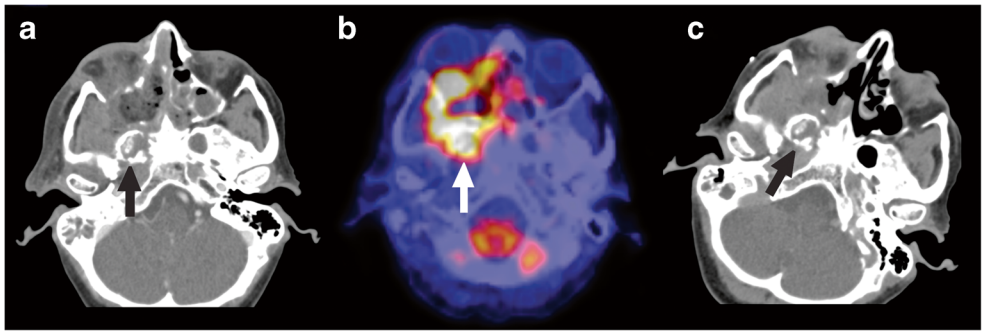


**Fig. 2** Aborted CT-guided intervention in a 78-year-old man who was referred for biopsy of a lesion in the right infratemporal space. Diagnostic CT scan and fused FDG-PET/CT show the lesion in the right infratemporal space that is partially calcified (**a**, arrow) and FDG-avid (**b**, arrow). After planning CT (**c**) and considering different angulations for needle insertion, it was decided that the risk of skull base penetration with the biopsy needle would be too high. Therefore, the procedure was aborted. No other subsequent invasive diagnostic intervention was done. The lesion decreased in size on follow-up imaging

institutions with different, generally less complex, patient populations. Second, only CT-guided biopsies, cytological aspirations, hookwire localizations, and catheter drainages were investigated. The results are applicable neither to ultrasound-guided or fluoroscopic procedures, nor to other interventions such as radiofrequency ablation, nerve block, joint injection, and cerebrospinal fluid aspiration. Third, diagnostic yields of biopsies and cytological aspirations, clinical outcome after catheter drainage, and effect of hookwire localization on surgery were not assessed, because this was beyond the scope of the study.

In conclusion, the frequency of canceled or aborted CT-guided interventions is low, but is not negligible. Awareness of causes and circumstances under which they are more likely

**Table 3** Univariate and multivariate logistic regression analyses on the association of patient age and gender, year in which the intervention was performed, type of intervention (biopsy, cytological aspiration, hookwire localization, or drainage), body region (lung, extremities, abdomen, spine, pelvis, sacrum, mediastinum, non-osseous chest wall, rib, head-neck, sternum, heart-pericardium, abdominal wall, axilla, or breast), and type of target tissue (soft tissue or bone) with the occurrence of canceled or aborted CT-guided interventions

| Variable | Univariate analysis | | | Multivariate analysis | | |
|---|---|---|---|---|---|---|
| | Odds ratio | 95% CI | *p* value | Odds ratio | 95% CI | *p* value |
| Patient age (years, continuous scale) | 1.001 | 0.986–1.016 | 0.904 | – | – | – |
| Patient gender (male vs. female) | 1.263 | 0.722–2.207 | 0.410 | – | – | – |
| Year of intervention (years, continuous scale) | 0.930 | 0.856–1.011 | 0.094 | – | – | – |
| Type of intervention (biopsy, cytological aspiration, hookwire localization, or drainage) | 3.111 | 1.608–6.020 | 0.001[a] | 2.677 | 1.178–6.083 | 0.019[b] |
| Body region (15 different body regions)[c,d] | 2.294 | 1.112–4.733 | 0.025[e] | 1.287 | 0.555–2.988 | 0.557[g] |
| | 7.571 | 2.073–27.648 | 0.002[f] | 6.956 | 1.883–25.691 | 0.004[h] |
| Type of target tissue (soft tissue vs. bone)[i] | 1.791 | 0.999–3.210 | 0.051 | – | – | – |
| Type of radiologist performing the intervention (radiologist with vs. radiologist without subspecialization in interventional radiology) | 1.375 | 0.615–3.075 | 0.456 | – | – | – |

[a] Drainages were significantly more likely to be canceled or aborted than biopsies and hookwire localizations (cytological aspirations were not included in the model); other variables did not reach significance

[b] Drainages remained significantly independently associated with being canceled or aborted

[c] Lung, extremities, abdomen, spine, pelvis, sacrum, mediastinum, non-osseous chest wall, rib, head-neck, sternum, heart-pericardium, abdominal wall, axilla, breast

[d] Three patients in whom two different body regions were targeted in one intervention session were not included in the logistic regression analysis

[e] Abdominal and [f] head-neck interventions were significantly more likely to be canceled or aborted than interventions in other body regions (abdominal wall, axilla, chest wall, heart-pericardium, mamma, mediastinum, sacrum, and sternum were not included in the model); other variables did not reach statistical significance

[g] Abdominal interventions did not remain significantly independently associated with being canceled or aborted, whereas [h] head-neck interventions did

[i] One patient in whom both soft tissue and bone in different body regions were separately targeted in one intervention session was not included in the logistic regression analysis

to occur may reduce the number of canceled or aborted CT-guided interventions.

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## Compliance with ethical standards

**Guarantor** The scientific guarantor of this publication is Thomas C. Kwee.

**Conflict of interest** The authors of this manuscript declare no relationships with any companies whose products or services may be related to the subject matter of the article.

**Statistics and biometry** No complex statistical methods were necessary for this paper.

**Informed consent** Written informed consent was waived by the local Institutional Review Board.

**Ethical approval** Local Institutional Review Board approval was obtained.

**Methodology**
- retrospective
- diagnostic study
- performed at one institution



## References

1. Haaga JR, Alfidi RJ (1976) Precise biopsy localization by computed tomography. Radiology 118:603–607
2. Haaga JR (2005) Interventional CT: 30 years' experience. Eur Radiol 15(Suppl 4):D116–D120
3. Kloeckner R, dos Santos DP, Schneider J, Kara L, Dueber C, Pitton MB (2013) Radiation exposure in CT-guided interventions. Eur J Radiol 82:2253–2257
4. Guberina N, Forsting M, Ringelstein A et al (2018) Radiation exposure during CT-guided biopsies: recent CT machines provide markedly lower doses. Eur Radiol 28:3929–3935
5. Nattenmüller J, Filsinger M, Bryant M et al (2014) Complications in CT-guided procedures: do we really need postinterventional CT control scans? Cardiovasc Intervent Radiol 37:241–246