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Study to Assess Radiation Exposure in Cases of Polytrauma Undergoing PAN-CT Scans in a Tertiary Hospital

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Abstract

Polytrauma requires swift and comprehensive imaging, with whole-body CT (Pan-CT) often employed as a diagnostic tool. However, Pan-CT scans carry significant radiation risks. This study quantifies radiation exposure in polytrauma patients undergoing Pan-CT and assesses its implications in the context of radiation safety guidelines. The mean effective dose was 52.42 mSv, with 62% of patients exceeding the annual occupational exposure limit of 20 mSv. Lifetime attributable risk (LAR) analysis revealed a potential 2.62% increase in cancer risk, underscoring the importance of optimizing scan protocols and monitoring exposure.

Keywords: Hypothesis, ICRP, Polytrauma, Radiation

Introduction

Polytrauma is a leading cause of morbidity and mortality, necessitating rapid imaging to identify life-threatening injuries. Pan-CT, while efficient, exposes patients to high radiation doses, raising concerns about long-term risks, particularly for younger individuals or those requiring repeat imaging. This study evaluates radiation doses from Pan-CT scans in polytrauma cases and emphasizes protocol optimization to mitigate these risks[1,2].

Aims

1. To quantify effective radiation doses in polytrauma patients undergoing Pan-CT.
2. To assess clinical significance in relation to radiation safety guidelines[3].

Inclusion Criteria

- Polytrauma patients undergoing ≥3 CT studies, including at least one body scan (chest, abdomen, or spine).
- Age ≥18 years.
- BMI between 18.5 and 29.9 kg/m²

Exclusion Criteria

- Non-trauma patients undergoing multiple CT scans.
- BMI less than 18.5 or greater than 29.9 kg/m²
- Patients with incomplete dose data.

Protocol:

For all Pan-CT scans performed:

- Head CT was conducted with the following parameters on average:
  - 225 mAs and 120 kVp.
- Body CTs (chest, abdomen, and pelvis) were performed with the following parameters on average:
  - 150 mAs and 120 kVp.

Materials and Methods

Fifty polytrauma patients underwent Pan-CT scans as part of their diagnostic workup. Dose-Length Product (DLP) values for each scan (head, chest, abdomen, etc.) were recorded from the CT console. Effective doses (mSv) were calculated using International Commission on Radiological Protection (ICRP) conversion factors[4]:

- Head: 0.0021
- Chest and abdomen: 0.014–0.015.

Data analysis included mean, median, minimum, maximum doses, and statistical assessments.

Results

Retrospective Study was done over a period of 3 months in a tertiary hospital equipped with 120 slice CT scanner (FUJI)

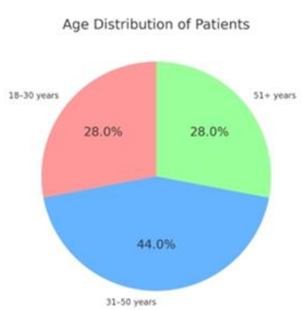
Duration of study: 3 months

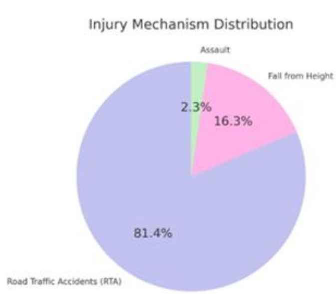
Sample population: 50 consecutive polytrauma patients who fit the inclusion criteria were sampled.

Average number of scans per day = 2.2 scans per day.

Demographics

The study population comprised 50 patients, including 43 males (86%) and 7 females (14%).





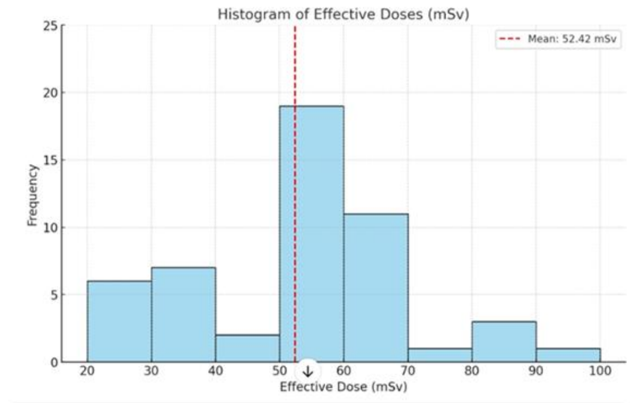
Age Distribution:

- The age of the patients ranged from 18 to 75 years, with a mean age of 36.2 years.

Injury Mechanism:

The primary causes of polytrauma in this cohort were:

- Road Traffic Accidents (RTA): 35 patients (70%)
- Fall from height: 7 patients (14%)
- Assault: 1 patient (2%)



1. **Effective Dose Distribution:**
   - Mean Dose: 52.42 mSv.
   - Range: 21.47–95.39 mSv.
   - 62% exceeded the occupational exposure limit (20 mSv/year) [5,6].
2. **Statistical Significance**
   - Hypothesis: Mean effective dose > 20 mSv (occupational threshold).
   - Test: One-sample t-test.
   - $$t = \frac{\bar{X} - \mu}{s/\sqrt{n}} = \frac{52.42 - 20}{17.20/\sqrt{50}} = 13.33.$$
   - p<0.001 confirming significantly higher exposure compared to the occupational threshold[7].
3. **Lifetime Attributable Risk (LAR) Analysis**
   - Formula:
     Individual LAR=Effective Dose (mSv)×0.0005
   - Mean Risk: 52.42×0.0005=0.02621 or 2.621%
   - Group Risk: Approximately 1 in 38 patients.
   - For the maximum dose (95.39 mSv): 95.39 × 0.0005=4.77% or 1 in 21 patients.

(This is an estimate based on the LAR model with an approximate value. The actual risk of cancer may vary depending on individual factors, such as age, sex, and genetic predisposition.)

Discussion

The findings demonstrate that radiation exposure during Pan-CT is substantial, often exceeding safety thresholds.

The significant LAR values highlight the potential long-term cancer risk, particularly for younger patients or those requiring multiple scans[8,9].

Recommendations for Optimization

1. **Monitoring Radiation Exposure:**
   Introducing a 'Radiation Exposure Card' for tracking cumulative doses in patients undergoing repeated imaging can provide valuable data for risk assessment.
2. **Reducing Unnecessary Exposure:**
   - Eliminate redundant phases in CT protocols.
   - Implement Automatic Exposure Control (AEC) and Iterative Reconstruction Algorithms, which can significantly lower radiation dose while maintaining acceptable image quality[10,11].
   - Using shields to reduce exposure to parts non relevant to the exposure (eg. Using gonadal shields).
3. **Balancing Dose Reduction and Image Resolution:**
   While reducing dose can compromise resolution, optimization techniques should aim for an acceptable trade-off to ensure diagnostic accuracy. For instance, chest and abdomen scans—key contributors to dose—can be optimized to balance detail and dose[12,13].
4. **Assessing the Need for CT:**
   Routine use of Pan-CT in all polytrauma patients may not be justified. A clinical assessment protocol should guide CT utilization to avoid unnecessary scans and radiation[14].

Conclusion

Pan-CT is an indispensable tool in trauma imaging but carries considerable radiation risks. Strategies to optimize imaging protocols, monitor exposure, and assess clinical necessity can significantly reduce long-term risks without compromising diagnostic outcomes.

Limitations of the Study

1. **Single Hospital Setting and variation in CT scanner types:**
   - Conducting the study in only one tertiary hospital limits the external validity of the findings. Different hospitals may use different CT machines, scanning protocols, or radiation dose reduction technologies. Similarly, different CT scanners (e.g., 64-slice, 128-slice, or 256-slice machines) may have different radiation dose profiles, and the results of this study may not be directly applicable to institutions with other types of equipment.
2. **Potential Confounding Factors:**
   - There are several potential confounding factors that were not controlled for in this study. For example, patient characteristics such as age, clinical indications for the scan, and the specific CT protocols used (e.g., variation in scan duration or scan phases) could all impact the measured radiation dose.
3. **Limited Dose Estimation Method:**
   - The Lifetime Attributable Risk (LAR) was estimated based on effective doses calculated using ICRP conversion factors. While these models provide a useful estimate, they rely on assumptions about cancer risk and may not capture individual variations, such as patient-specific risk factors (e.g., genetic predisposition, underlying health conditions), which could affect the actual lifetime cancer risk.

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