Pediatric Head CT: Causes Of And Strategies To Reduce Excessive Radiation Dose

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Abstract

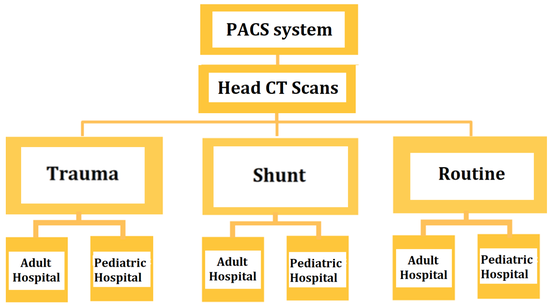
CT scans are the leading contributor to medical radiation exposure in the U.S. High levels of such exposure pose significant health risks for children. **This project aims to** increase the safety of CT imaging of the head for pediatric patients nationwide by identifying causes of excess radiation dose and using these conclusions to determine effective strategies healthcare systems may implement to reduce rates of excessive radiation dose. **We hypothesized that** failure to adjust CT scanners to pediatric settings in adult hospitals contribute to excessive radiation dose. **To test this hypothesis**, mean radiation dose (Total Exam DLP) and CTDIvol from CT scans for Shunt, Routine, Trauma were compared between adult versus pediatric hospitals in149 pediatric patient cases. **Results demonstrated that** pediatric patients who received head CT scans for trauma or routine CT scans at adult hospitals received significantly higher radiation doses when compared to those who received CT scans at pediatric hospitals**. Results therefore supported the hypothesis that** failure to adjust CT scanners to pediatric settings in adult hospitals is a significant contributor to unnecessarily high radiation dose during the CT scanning process for pediatric patients. **In conclusion**, to increase the safety of CT scans for pediatric patients, healthcare systems should ensure CT scan protocols are adjusted to pediatric settings when scanning children.

Introduction

- In the U.S., **CT scans** are the **leading** contributor to **medical radiation exposure**. [1]
- High levels of **radiation** from CT scans put children at **significant health risks**. [2]
- After receiving an **identical** radiation dose, a **child** has a **significantly higher risk** of radiation-related **cancer** compared to **adults**. [3]
- It is therefore imperative to ensure that pediatric CT protocols **minimize radiation dose**.
- **Despite existing attempts** to optimize radiation dose, cases of **inappropriate** radiation dose for pediatric head CT scans **still occur**.
- The **development** of **effective strategies** to **further decrease rates** of excess radiation are therefore needed.
- **Development** of **effective strategies** to reduce rates of inappropriate radiation dose in pediatric CT **requires** an understanding of **why cases of high radiation dose still occur.**
- Few studies have **elucidated causal factors** for why cases of excess radiation dose still occur **despite existing efforts** to limit them.
- Without knowledge of **the causes** of continued excess radiation use, it is **not possible** for healthcare systems to **determine** what **changes** would be **effective**.
- This **lack of knowledge** therefore poses a **substantial barrier** to optimizing radiation doses.
- **This project** sought to **suggest effective strategies** to reduce unnecessarily high radiation dose in pediatric head CT scan protocols **by identifying fundamental causes** of excess radiation use in hopes of increasing the **safety** of **head CT scans** for **children across the nation**.

Methodology

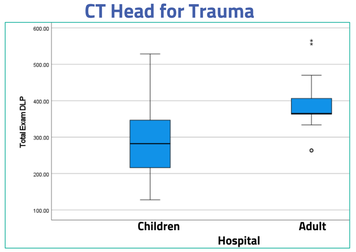
- **Head CT scans** of 149 **pediatric patients** from **8** hospitals across the **Eastern U.S** were assessed.
- *Adult hospital refers to hospitals serving **both adult** & **pediatric patients**.
- *Pediatric hospital refers to hospitals serving **pediatric patients exclusively**
- **Total Exam DLP** & **CT Dose Index** (**CTDIvol**) (*measures of radiation dose*) were obtained using Picture Archiving and Reporting System (**PACS**), where patient imaging data is stored.



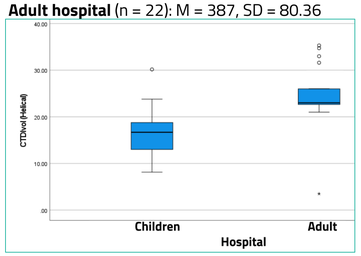
- Head CT scans for **3 chief complaints** were analyzed:
  - **Trauma**
  - **Shunt**
  - **Routine** (non-trauma related)
- Some examples of **routine** indications are headaches, altered mental status, and developmental delay.
- A **t-test for independent samples** was used to compare **mean Total Exam DLP** and **mean CTDIvol** of Head CT scans between **adult** and **pediatric hospitals** for each chief complaint

Results

CT Head for Trauma



Total Exam DLP (mGy/cm): *t*(56) = -3.258, ***p* = .002**
Pediatric hospital (n = 34): M = 287, SD = 88.54
Adult hospital (n = 22): M = 387, SD = 80.36

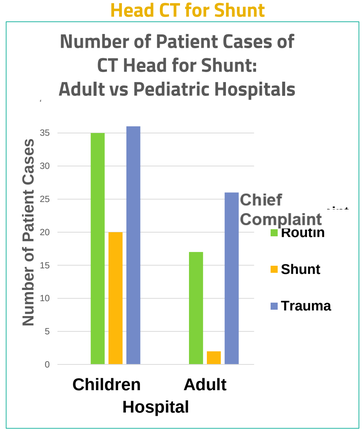


CTDIvol (mGy): *t*(56) = -4.530, ***p* <.001**
Pediatric hospital (n = 34): M = 16.5
Adult hospital (n = 22): M = 23.684

t test for Independent Samples:
Comparing Mean **Total Exam DLP** & Mean **CTDIvol** between **Pediatric** vs. **Adult** Hospitals

	t	Two-Sided p	Std. Error Difference	95% Confidence Interval	
				Lower	Upper
Total Exam DLP	-3.258	**.002**	27.142	-142.848	-34.014
CTDIvol	-4.530	**<.001**	1.576	-10.302	-3.979

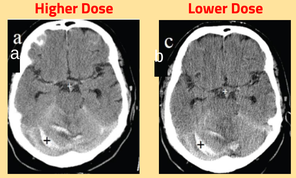
Head CT for Shunt



*Too **few cases** of Head CT for **shunt** at **adult hospitals** in **our patient sample** for t-test analysis or any meaningful comparison.*

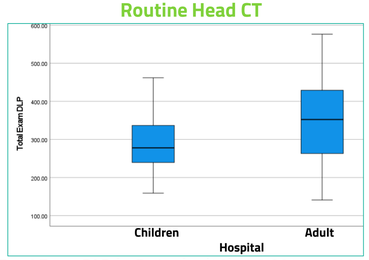
Comparing CT Image Quality
High Dose vs Low Dose scans

Higher Dose **Lower Dose**

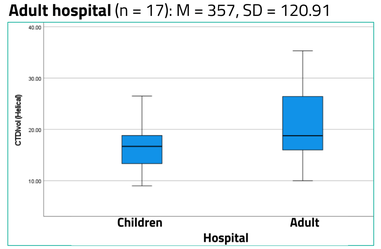


Patient with traumatic bleeding into the right cerebellum. Initial head CT (**a**) with higher dose and follow-up scan next day (**b**) with lower dose. **The hyperdense blood is equally well visible on the higher dose and the lower dose CT scans.** [4]

Routine Head CT



Total Exam DLP (mGy/cm): *t*(49) = -2.394, ***p* = .021**
Pediatric hospital (n = 32): M = 289, SD = 78.32
Adult hospital (n = 17): M = 357, SD = 120.91



CTDIvol (mGy): *t*(49) = -2.164, ***p* = .035**
Pediatric hospital (n = 32): M = 16.411
Adult hospital (n =17): M = 20.873

t test for Independent Samples:
Comparing Mean **Total Exam DLP** & Mean **CTDIvol** between **Pediatric** vs. **Adult** Hospitals

	t	Two-Sided p	Std. Error Difference	95% Confidence Interval	
				Lower	Upper
Total Exam DLP	-2.394	**.021**	28.509	-125.599	-10.893
CTDIvol	-2.164	**.035**	1.780	-7.431	-.273

Conclusions

- Pediatric patients who received head CT scans for **trauma** at **adult hospitals** compared to those who received head CT scans for **trauma** at **pediatric hospitals** had **significantly higher Total Exam DLP (*p* = *.002*),** and **significantly higher CTDIvol (*p* <*.001*).**
- Pediatric patients who received **routine** head CT scans at **adult hospitals** compared to those who received **routine** head CT scans at **pediatric hospitals** had **significantly higher Total Exam DLP (*p* = *.021*)** and **significantly higher CTDIvol *(p = .035).***
- **Repeat scanning** for motion **was not a major contributing factor to excess radiation** dose, as there was only 1 case of a repeat scan in our sample. This further underscores that **excess radiation dose is primarily due to a lack of optimization of scan parameters to pediatric settings.**
- The greater number of **outliers with high doses** at adult hospitals for routine scans also indicates a **lack of standardization** of protocols.
- **Results demonstrated that** pediatric patients who received head CT scans for **trauma** or **routine** head CT scans at **adult hospitals** received **significantly higher radiation doses** when compared to those who received head CT scans at **pediatric hospitals.**
- **Results therefore supported the hypothesis** that failure to adjust CT scanners to pediatric settings in adult hospitals is a significant contributor to unnecessarily high radiation dose.
- **In conclusion**, to increase the safety of head CT scans for children, healthcare systems should ensure protocols are adjusted for pediatric patients.

References

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4. Blasel S, Huck L, Konczalla J, Lescher S, Ackermann H, *et al.* Low Dose CT of the Brain in the Follow-up of Intracranial Hemorrhage. *Int J Radiol Imaging Technol* 2016;2:015.

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