100K Children Campaign

Safe Imaging

Washington State Hospital Association

Partnership for Patients

ALASKA STATE HOSPITAL & NURSING HOME ASSOCIATION

Washington State Hospital Association

"Maximizing long-term health of our children by ensuring safe imaging in health care."

Updated October 2017

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To download a copy of this toolkit, go to
http://www.wsha.org/quality-safety/projects/100k-children-campaign/

Contents

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Children's Radiation Safety

Executive Summary

Optimizing Radiation, Reducing Risk

Radiation awareness is at an all-time high. Families are concerned about their children being exposed to unnecessary ionizing radiation. The Washington 100K Children Campaign goal is to minimize childhood exposure to ionizing radiation as an everyday practice through dose optimization and reduction in high dose studies. Eliminating overuse of imaging procedures results in better care, better health, and lower health care costs.[i]

Hospitals and health systems in the Pacific Northwest region have reduced radiation dose for computed tomography (CT) examinations in the pediatric population, but dose variation still exists and patients are being exposed to unnecessary CT procedures and radiation.

- An estimated 4 million CT scans performed on children each year could result in 5,000 future cancer diagnoses.[ii]
- CT scans which have increased 10% percent each year over the past 15 years are responsible for over 40 percent of cumulative diagnostic radiation exposure.[iii]
- Among children aged 5 to 14, CT use nearly tripled, from 10.5 per 1,000 in 1996 to a peak of 27 per 1,000 in 2005, before falling to about 24 per 1,000 in 2010.[iv]
- Reducing unnecessary and high-dose pediatric CT scans could cut associated cancers by 62 percent.[iv]

Our region has become a leader in safe imaging for children. Research shows that the use of protocols and decision making tools assists physicians in making the right diagnostic choice such as ordering an ultrasound before a CT for suspected appendicitis or observation for pediatric patients with minor head trauma rather than immediately defaulting to a CT scan of the brain. If a CT is clinically necessary, physicians should order a single phase CT scan using size-or-age-specific pediatric patient protocols. Ultimately, reducing and/or removing the instances of unnecessary radiation reduces future cancer risk from direct medical radiation exposure.

Pacific Northwest Region Partnering with National Leaders

- Children are considerably more sensitive to radiation than adults, as demonstrated in epidemiologic studies of exposed populations.[v]
- Children have a longer life expectancy than adults, resulting in a larger window of opportunity for expressing radiation damage.[v]
- Children may receive a higher radiation dose than necessary if CT settings are not adjusted for their smaller body size.[v]

The Washington 100K Children Campaign has spawned many similar programs in alignment with the guidelines and recommendations set forth by the **Choosing Wisely**[vi] and **Image Gently**[vii] campaigns. The Washington 100K Children Campaign has provided a vehicle for hospitals and health systems to standardize pediatric imaging processes and identify and learn from best practices locally.

The current WSHA Children's Radiation Safety initiative is a collaborative effort with:

- Centers for Medicare & Medicaid Services (CMS)
- American College of Radiology (ACR)
- American College of Emergency Physicians (ACEP)
- Rural Healthcare Quality Network (RHQN)
- 100K Children National Campaign
- Washington University Medical School – St Louis
- The Mayo Clinic

Choosing Wisely®
An initiative of the ABIM Foundation

image gently® The Alliance for Radiation in Pediatric Imaging

For questions or more information contact safeimaging@wsha.org.

Keys to Success

- **Right Study**
  - CT Head with IV Constrast

- **Right Order**
  - Single phase CT exams ordered instead of dual phase studies
  - Observation ordered for minor head trauma instead of a head CT
  - Ultrasound used as the first option for suspected appendicitis

- **Right Way**
  - Pediatric CT protocols developed and consistently used

- **Right Report**
  - Total dose length product (DLP) of CT studies monitored, measured and recorded

- **Right Action**
  - Quality data and performance improvement reported to organizations' Quality Committee

Strategies

1. **Optimizing DLP** (Dose Length Product) – ensuring that DLP is appropriate for a patient's age and that protocols are structured to support imaging exam DLP end-values within acceptable ranges to optimize safety and ensure clinically viable images. WSHA supports Dose Index Registry[viii] as a platform.

2. **Supporting Child-Sized Protocols** – adjusting the parameters of an exam to fit the pediatric patient based on age and/or size categories for imaging exam DLP end-values is expected to optimize safety and clinical image quality, noting that one size does not fit all. WSHA supports updating protocols to align with the age categories of the Dose Index Registry (ages 0 to 2, 3 to 6, 7 to 10, 11 to 14 and 15 to 18). Additional categories or subcategories may be determined by a physicist and radiologist.

3. **Disseminating PECARN** – educating ordering providers around identifying children at low risk for clinically important traumatic brain injuries may reduce unnecessary exams based on the 2009 Kuppermann[ix] study, thus optimizing when exams are ordered. WSHA supports R-SCAN[x] as a platform.

Stakeholders

Providing safe imaging for children involves multiple stakeholders. Identified stakeholder groups include:

- **Technology** – Radiologic Technologists, Radiologists and Physicists
- **Ordering** – Physicians, Physician Assistants, Nurse Practitioners and other Licensed Providers
- **Quality** – Performance Improvement, Quality and Risk, and Administrators
- **Governing** – Clinical and Quality Leaders, Executives, Regulatory and Advisory Groups
- **Patients and Families** – Recipients of Imaging Care and Parents

One of the major challenges for a regional Children's Radiation Safety initiative is bridging the gaps between disparate stakeholder groups, each of which has differing concerns and require tailored messaging and support.

Quality and Technology Stakeholders

Facilitating collaboration may prove difficult in the absence of national benchmarks for data review and comparison since the dose of radiation delivered depends on numerous factors, including the specific brand and model of CT scanner, slice capacity, the imaging exam ordered, the age and size of the patient, positioning, scanner acquisition settings, rotation time, time of exposure, usage of riterative adiation dose reduction methods, tube current and many other variables. Compounding these variables are specialized terms specific to each brand of CT scanner for the same or similar processes and features.

CT scanner data, such as the dose of radiation delivered during an exam, is often not directly accessible to quality leaders since CT scanner software is typically isolated from electronic medical records. Participating in a national registry allows specialize software to automatically export data from CT scanners, but not all hospitals have access to these platforms. If data is not automatically exported, then communication and coordination between Quality and Technology stakeholders is required to first extract the data before reporting it.

Ordering and Technology Stakeholders

Physicians and other providers who care for children are charged with ordering exams to assist in diagnoses, but not all clinical practitioners who order imaging studies understand the more technical considerations or nuances of optimizing radiation dose. Most ordering providers simply require a clear radiologic image on which to base therapeutics interventions. As such, a tendancy to use a higher dose of radiation than necessary may exist to unsure viable images.

The Ordering stakeholder group is more concerned with whether or to an imaging exam is warranted. If an exam is deemed unnecessary, then the children receives no undue radiation. However, if the exam was needed, but not conducted, consequences may follow.

Governing Stakeholders

Executives and other leaders are tasked with ensuring patient safety, maintaining viable operations and safeguarding public health. Balancing the risks and benefits of imaging studies requires insight to support operational decisions. Funding new CT scanners, equipment upgrades, provider or technologist training, registry participation or purchasing software applications must be evaluated in the context other pressing expenditures. And the value optimizing doses of radiation versus ensuring well-defined images with slightly higher doses can be uncertain.

Patients and Families as Stakeholders

The parents of children who have been unjured need assurances from their care providers that everything that can be done to ensure the safety of their child has been done. In many situations a child's likelihood of having an injury that was not detected, based on observing the child rather than ordering an imaging study, is less than the child's risk of developing a malignancy later in life. This, however, can be a lengthy or unpopular conversation.

The chart of terms below from the American College of Radiology[xi] is helpful for all stakeholder groups:

Radiation Units in Computed Tomography

Term	Description	Unit
CT Dose Index (CTDIvol)	Radiation energy absorbed per unit mass - for CT, determined for a standard phantom and not a patient	gray (Gy) or milligray (mGy)
Dose Length Product (DLP)	Absorbed dose (CTDIvol) times the length of the exposure - for CT, determined for a standard phantom and not a patient	milligray-cm (mGy-cm)
Size Specific Dose Estimate (SSDE)	A patient dose estimate which takes into consideration corrections based on the size of the patient	milligray (mGy)

https://www.acr.org/~/media/ACR/Documents/PDF/QualitySafety/NRDR/DIR/DIRPedSampleReport.pdf?db=web (page 6)[xi]

The following steps will help guide a successful implementation strategy. Many of the steps can be implemented at the same time. Tools and resources are linked throughout the document to assist with the implementation process.

Implementation Steps

Step 1: Engage Stakeholders

- Assemble a multidisciplinary team.
- Tell a story from the Reducing Undue Radiation Exposure initiative.
- Share data from hospitals participating in the initiative.
- Identify which pediatric studies will be the first implemented.

Step 2: Implement Policies, Procedures, Protocols and Algorithms

- Adopt policies, define procedures and implement protocols.
- Refine procedures and protocols.
- Utilize decision support tools and algorithms.

Step 3: Educate and Collaborate

- Collaborate with radiology staff, radiologists, physicists, ordering physicians and ED staff.
- Identify champions for dose optimization and radiation safety.
- Educate board members and executive leaders.

Step 4: Evaluate Success

- Monitor monthly dose reports from existing data.
- Collect, monitor and report CT head DLP.
- Collect, monitor and report utilization rate of the PECARN algorithm for minor head trauma.
- Share data monthly with forums at all levels from the hospital board to key stakeholders.
- Compare DLP values through enrollment in a national registry or with the Dose Index Registry (DIR) Pediatric Sample Report.

Step 5: Hardwire Excellence

- Collect staff input to evaluate need for changes in the process.
- Continue to develop policies, define procedures and refine protocols.
- Continue to support the utilization of decision support tools and algorithms.
- Spread to other Washington State facilities and nationally to promote success.
- Celebrate successes.

Step 1: Engage Stakeholders

Assemble a Multidisciplinary Team

Implement a multidisciplinary team who will meet monthly and as needed to review data and monitor ongoing performance and present recommendations. Members of the committee should include a pediatric surgeon, emergency physician, hospitalist, radiologist, radiologic technologist, medical physicist, and quality and safety partner. *Physician champions are essential for success* in the implementation and should include a radiologist, pediatric surgeon, and/or or emergency department physician. The initial physician champion will assist with the interventions as well as communications with physician groups as needed, but the initiative will require participation from each of the department sections to meet the outlined objectives. Engage a senior executive such as a vice president or higher level who will support staff and physicians during implementation. Other key individuals to engage are the following:

Radiology Medical Director or Chief of Radiology

- ☐ Supports initiative
- ☐ Monitors imaging quality
- ☐ Provides feedback to Imaging Services Director
- ☐ Assures results are shared with radiologists
- ☐ Helps to disseminate results and share stories

Medical Imaging Operations Director

- ☐ Supports initiative
- ☐ Manages resources
- ☐ Assures results are shared with staff
- ☐ Assigns project leaders to interventions
- ☐ Coordinates executive education
- ☐ Verifies results are reviewed in a timely manner
- ☐ Monitors progress
- ☐ Helps to disseminate results and share stories

Radiologic Technologist

- ☐ Supports initiative
- ☐ Implements pediatric protocol development and annual protocol review
- ☐ Collects data
- ☐ Performs quality audits and review data with staff technologists
- ☐ Helps to disseminate results and share stories

Quality and Safety Partner

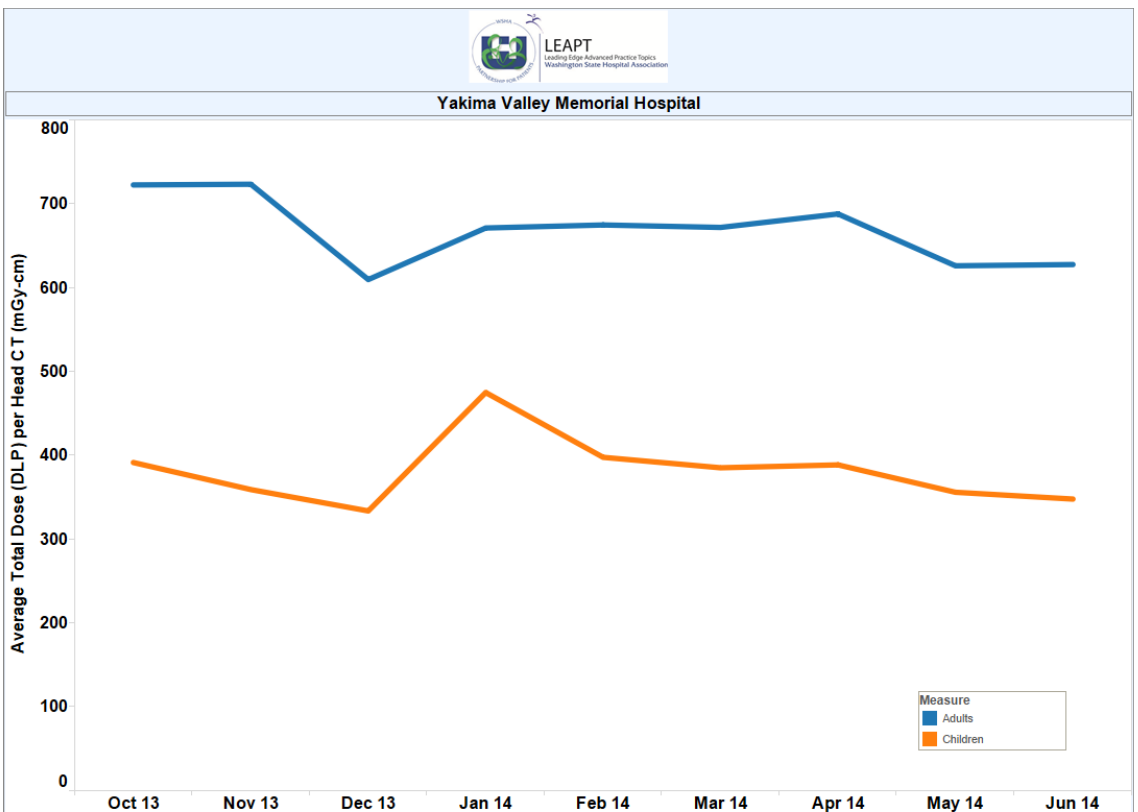
- ☐ Supports initiative
- ☐ Analyzes and reports data
- ☐ Report quality data to senior leaders

Tell a Positive Story

Virginia Mason Memorial Hospital (VMMH), previously Yakima Valley Memorial Hospital, is a regional leader in radiation dose optimization. They used an incremental dose reduction process with input from a multidisciplinary team and a new technology application to achieve a 56 percent reduction in the delivered radiation dose for computed tomography (CT). Optimal image quality was maintained at the lowest possible dose.

An initial key strategy to VMMH's success was to understand their current CT radiation dose levels by creating a database of dose records to establish individual baselines for all CT scan categories. The dose records included three measurements; dose length product (DLP), CT Dose Index Volume ($CTDI_{vol}$) and scan length. Radiology leaders collaborated with their radiologists to identify internal diagnostic reference levels and set dose goals for the individual scan categories. Incremental changes were applied over several weeks until a 25 percent reduction was achieved.

The second key strategy was the implementation of iterative reconstruction software. This technology allowed an additional 31 percent reduction in CT dose while still mainting the quality of the image. VMMH continues to record CT dose and perform quality checks to ensure that they are sustaining their achieved dose reduction and maintaining image quality for adult and pediatric patients.



Definition: Average DLP per Head CT (mGy-cm): Average Total Dose (DLP) per Head CT (mGy-cm).
Data Source: Facility direct report to WSHA
Baseline calculated from all available data (18 observations) from Q4 2013

Share Data

- Post a graph with the rate of observation, use of ultrasound, and single phase studies.
- Post a graph with total DLP for head CT.
- Post graphs with trend lines so imaging staff, radiologists and ordering physicians can see at a glance your rate and how it is changing over time.
- Share national data from the American College of Radiology's Dose Index Registry.
- Distribute reports to executives, imaging services staff, radiologists and ordering physicians.

- ➢ Post the number of studies with DLP in the appropriate range for age.
- ➢ Post the number of days (weeks or months) with an increasing trend in percent of PECARN utilization or observation ordered for minor head trauma in children.
- ➢ Post the number of days (weeks or months) with an increasing trend in percent of ultrasounds ordered for suspected appendicitis in children if your initiative tracks this.
- ➢ Post the number of days (weeks or months) with an increasing trend in the percent of single phase CT ordered if your initiative tracks this.
- ➢ Post the number of studies performed on children using size- or age-specific protocols.
    - Each elementary school has an attendance average of 500 children
    - 500 appropriately deferred CT scans = one elementary school
    - 100K such clinically appropriate choices = 200 elementary schools

- Use formal and informal opportunities to talk about the interventions and adopt strategies to succeed.
- Make a point of recognizing providers who appropriately follow the protocol.
- Invite your hospital executive to become an active part of your clinical area's improvement team and draw on their expertise to help with your specific challenges.
- Share data at department level and all the way up to board meetings.

Celebrate the goals you achieve and promote safe imaging for children across Washington.

100K Children Campaign Measures Adopted by Other Organizations

Reducing Number of Studies

Percent Pediatric Patients Receiving Observation for Minor Head Trauma using the Pediatric Emergency Care Applied Research Network (PECARN) Pediatric Head Injury/Trauma Algorithm

Numerator: Number of pediatric patients treated in the emergency department for minor head trauma in the month that did not receive a head CT.
Denominator: Number of pediatric patients treated in the emergency department in the month for minor head trauma.

Percent Pediatric Patients Receiving Ultrasound for Suspected Appendicitis

Numerator: Number of pediatric patients in the month who had an ultrasound performed within 30 days prior to the diagnosis related to appendicitis.
Denominator: Number of pediatric patients with a primary or secondary diagnosis related to appendicitis in the month.

Percent Pediatric Single Phase Head Computed Tomography (CT)

Numerator: Number of pediatric inpatient and outpatient single phase head CTs performed in the month.
Denominator: Number of pediatric inpatient and outpatient single phase and dual phase head performed in the month.

Percent Pediatric Single Phase Chest Computed Tomography (CT)

Numerator: Number of pediatric inpatient and outpatient single phase Chest CTs performed in the month.
Denominator: Number of pediatric inpatient and outpatient single phase and dual phase chest performed in the month.

100K Children Campaign Measure Adopted by WSHA

Optimizing Dose by Updating Protocols and Adhering to Age Range Categories

Optimize Radiation Dose for Pediatric Head Computed Tomography (CT)

Numerator: Total Dose Length Product (DLP) for all pediatric head CTs performed in the month.
Denominator: Number of pediatric head CTs with recorded DLP performed in the month.

Current WSHA DLP Measure Definition for Dose Length Product (DLP)

Safe Imaging – DLP – Optimize Radiation Dose for Pediatric Head Computed Tomography (CT) Measure Definition Sheet

Data Definition – Optimize Radiation Dose for Pediatric Head Computed Tomography (CT)

Numerator: Total Dose Length Product (DLP) for all pediatric head CTs performed in the month.

Denominator: Number of pediatric head CTs with recorded DLP performed in the month.

Data Submission

1. Data will be submitted monthly to the Washington State Hospital Association (WSHA) **Quality Benchmarking System (QBS) 2.0**. The department code for this measure is Imaging. Current users may log in with their QBS credentials. If you need access to QBS, please contact your hospital's Quality Administrator or WSHA Decision Support at decisionsupport@wsha.org.

2. Baseline data: **2016.**

3. Ongoing: Monthly data to be submitted to QBS by 45 days after the end of the prior month.

Data Month	Submit By
January	March 15th
February	April 15th
March	May 15th
April	June 15th
May	July 15th
June	August 15th
July	September 15th
August	October 15th
September	November 15th
October	December 15th
November	January 15th
December	February 15th

Inclusion Criteria

Pediatric inpatients and outpatients including emergency department patients, **0 to 17 years of age**, who received a head CT associated with CPT codes **70450** (without contrast), **70460** (with contrast) and **70470** (without contrast followed by with contrast).

Suggested Instructions for Data Collection

Optimize Radiation Dose for Pediatric Head Computed Tomography (CT)

Numerator: Total Dose Length Product (DLP) for all pediatric head CTs performed in the month.

Denominator: Number of pediatric head CTs with recorded DLP performed in the month.

Generate a list of inpatients and outpatients including emergency department patients, 0 to 17 years of age, who receive a head CT with CPT codes 70450, 70460 and 70470. This is your **denominator.** From this list, add the total DLP for these patients. This is your **numerator**.

Note: Repeat studies should be separated as individual exams, as should each phase of 70470. Patients aged 18 and older are not included.

Step 2: Implement Policies, Procedures, Protocols and Algorithms

Adopt Policies, Define Procedures and Implement Protocols

Implement protocols, procedures, algorithms and guidelines to assist your hospital staff and clinicians make safer imaging choices for children. Pediatric protocols can refer to the technical specifications of each exam, as well as algorithms that support clinical descisions. This toolkit will reference protocols as the technical consideration and refer to decision support processes as algorithms to avoid confusion.

Refine Procedures and Protocols

- Review current radiation doses for pediatric head computed tomography (CT)
- Enroll in a national registry for dose reporting
- Utilize the ACR Sample Pediatric Reports for dose comparison and adjustments
- Comply with NEMA-XR-29 national standards for CT Scanners
- Review XR-29 embedded pediatric procolos for imaging (see Appendix B)
- Refine pediatric protocols to further optimize dose, as necessary (see Appendix B)
- Review options for iterative reconstruction (see Appendix A)
- Review options for tube current modulation and patient centering (see Appendix A)
- Consider aligning pediatric protocols with the five age ranges noted in the American College of Radiology Dose Index Registry for comparison[xi] (see Appendix B)
  - Ages 0 to 2
  - Ages 3 to 6
  - Ages 7 to 10
  - Ages 11 to 14
  - Ages 15 to 18

XR-29 pediatirc protocols are intended to reduce radiation, but not optimize doses delivered to pediatric patients. Many CT scanners reference two or three internal protocols, based on age ranges such as ages 0 to 6, 7 to 12 and 13 to 18. Refining these protocols further may be necessary for dose optimization. WSHA recommends aligning protocols for comparison with the five age categories in the American College of Radiology's (ACR) Dose Index Registry (DIR) Pediatric Sample Report. These age ranges are noted above[xi].

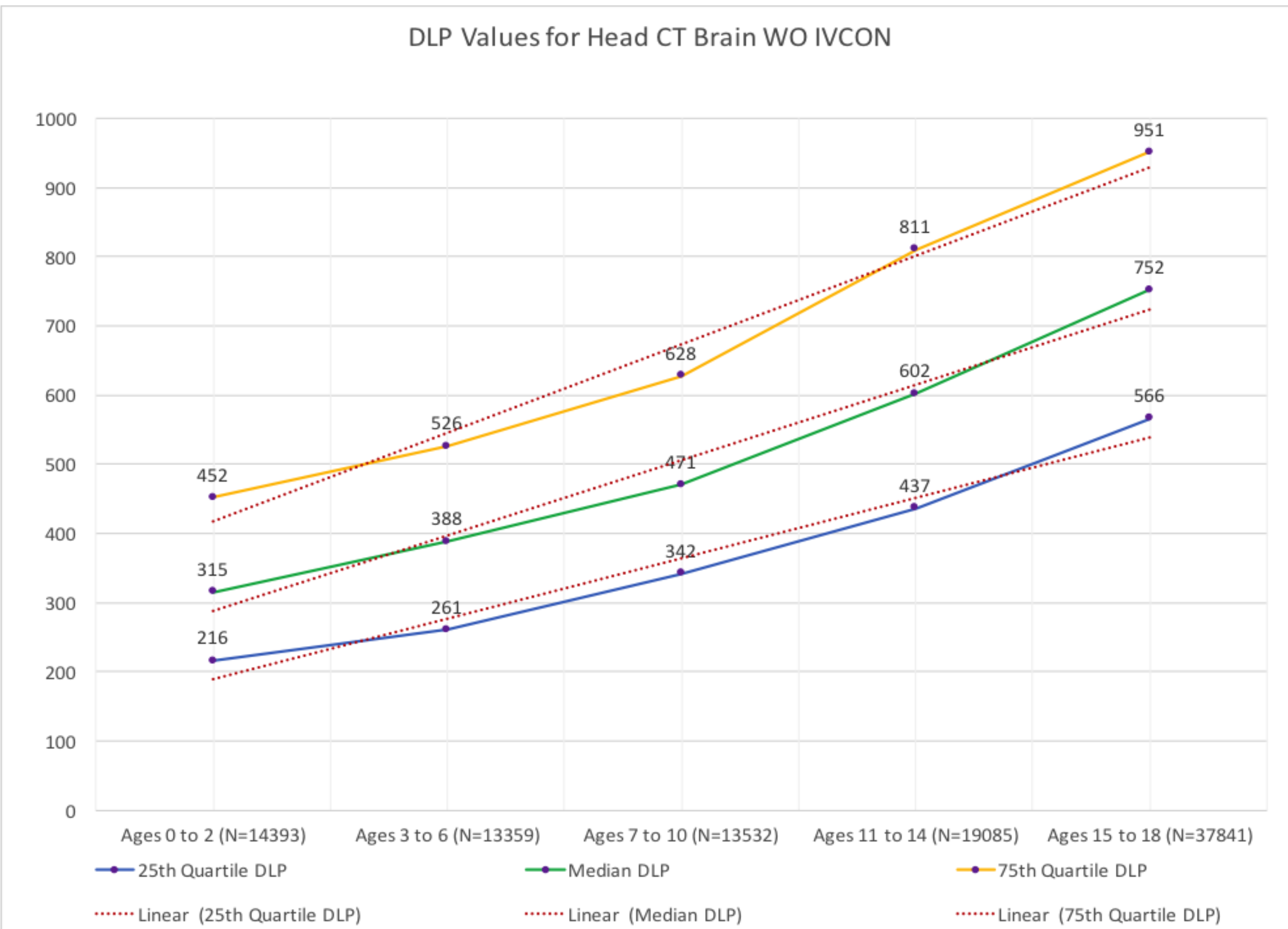
Reference Available Resources

The following image is a representation of DLP data values from the 2016 July-December American College of Radiology's Dose Index Registry (DIR) Pediatric Sample Report (page 18, column 2). The DIR was launched in 2011 and, as of July 2016, had data on 30.3 million examinations from 1524 facilities. This extensive participation and totally automated complete capture of all patient examinations enable the development of robust, clinically based national Diagnostic Reference Levels (DRLs) and Achievable Doses (ADs). However, DRLs and ADs have not been established for pediatric populations. These may be identified by 2020[xi].

Reference Available Resources (continued)

Each of three lines below illustrates the 25-quartile (blue), median (green) and 75-quartile (yellow) for DLP values for five age categories. These data are from 98,210 Pediatric Head CT studies conducted nationwide. While the initiative lacks national benchmarks such as DRLs and Ads for pediatric imaging, these data in the image above are our current best estimate for optimal dose-to-image performance, irrespective of CT scanner brand, model or slice. Each trend line (red) displays a linear progression of the radiation typically required to produce viable images as patients' age or size increase.

DLP Values from 98,210 Pediatric Head CT Imaging Studies



Data Set

- CT HEAD BRAIN WO IVCON DLP Ages 0-2 N=14393 (216/315/452)
- CT HEAD BRAIN WO IVCON DLP Ages 3-6 N=13359 (261/388/526)
- CT HEAD BRAIN WO IVCON DLP Ages 7-10 N=13532 (342/471/628)
- CT HEAD BRAIN WO IVCON DLP Ages 11-14 N=19085 (437/602/811)
- CT HEAD BRAIN WO IVCON DLP Ages 15-18 N=37841 (566/752/951)

https://www.acr.org/~/media/ACR/Documents/PDF/QualitySafety/NRDR/DIR/DIRPedSampleReport.pdf?db=web (page 18, column 2)[xi]

Utilize Decision Support Algorithms such as PECARN

Use the PECARN Pediatric Head Injury/Trauma Algorithm below to determine if observation is the appropriate choice for a pediatric patient presenting with minor head trauma rather than ordering a head CT. To use the PECARN Pediatric Head Injury/Trauma Algorithm:

1. Measure the **Glasgow Coma Scale** (GCS) to determine if the pediatric patient fits the required criteria for evaluation using the PECARN algorithm. The Glasgow Coma Scale is based on a 15 point scale for estimating and categorizing the outcomes of brain injury on the basis of overall social capability or dependence on others. The minimum score is 3 points which designates a deep coma or brain death. The GCS test measures the motor response, verbal response and eye opening response with these values[ix].

I. **Motor Response**
6 – Obeys commands fully
5 – Localizes to noxious stimuli
4 – Withdraws from noxious stimuli
3 – Abnormal flexion, i.e. decorticate posturing
2 – Extensor response, i.e. decerebrate posturing
1 – No response

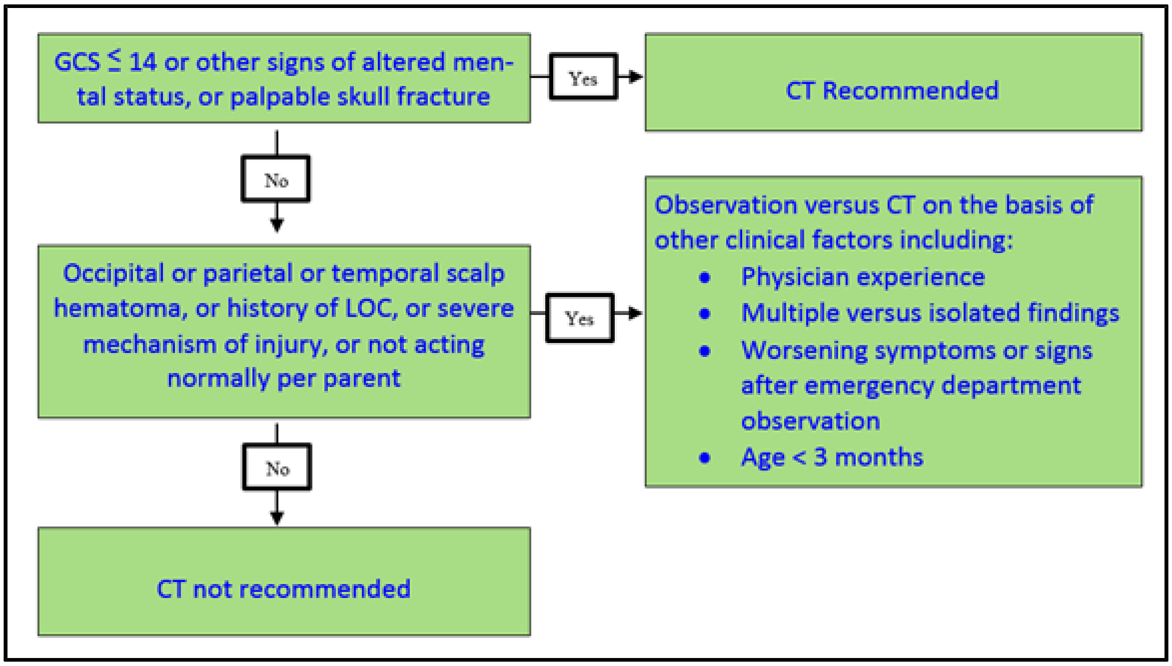
II. **Verbal Response**
5 – Alert and Oriented
4 – Confused, yet coherent, speech
3 – Inappropriate words and jumbled phrases consisting of words
2 – Incomprehensible sounds
1 – No sounds

III. **Eye Opening**
4 – Spontaneous eye opening
3 – Eyes open to speech
2 – Eyes open to pain
1 – No eye opening

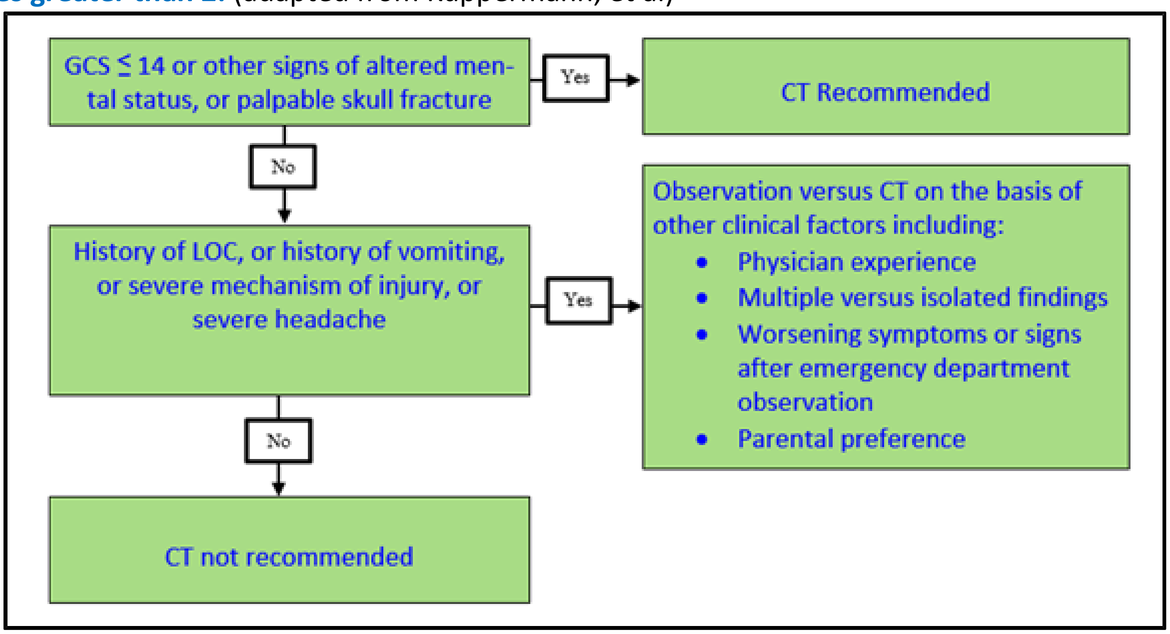
2. Determine the GCS by adding the values of I + II + III.
This number helps medical practitioners categorize the four possible levels for survival, with a lower number indicating a more severe injury and a poorer prognosis:
Mild = GCS Score of 13-15
Moderate Disability = GCS Score of 9-12
Severe Disability = GCS Score of 3-8

3. Apply the PECARN Pediatric Head Injury/Trauma algorithm and validate your recommendation with your clinical findings.

For ages less than 2: (adapted from Kuppermann, et al)[ix]



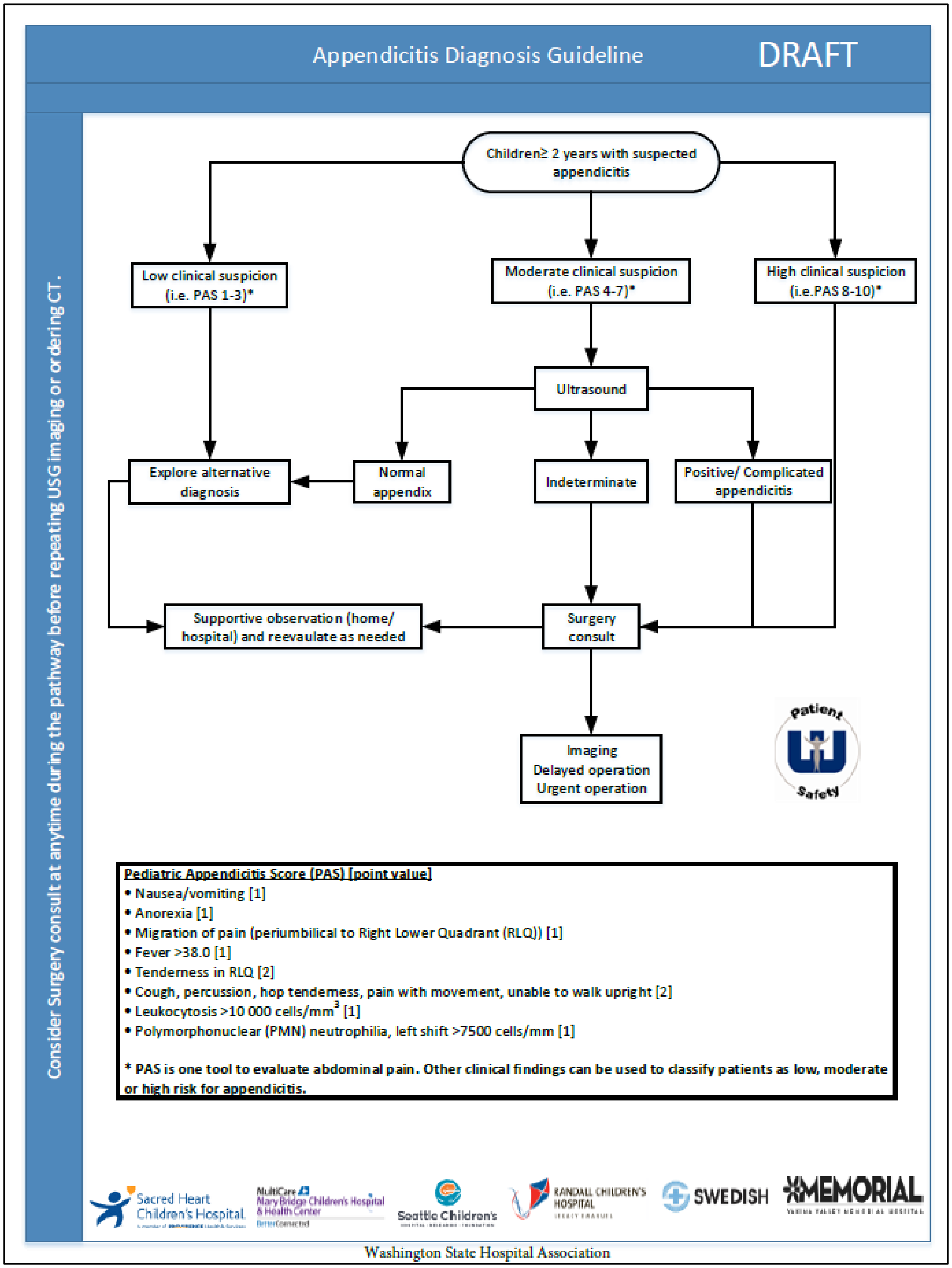
For ages greater than 2: (adapted from Kuppermann, et al)[ix]



Summary: If GCS is **13** or less, a CT scan is recommended. If GCS is **14**, a CT scan is still recommended as there is a 4.4% chance of missing a clinically important Traumatic Brain Injury (ciTBI). If GCS is **15**, then the ordering provider must decide if an imaging study is warranted, as the risk for magliganacies later in life from radiation exposure may exceed the risk associated with a ciTBI.

See also WA DOH Resource: http://www.doh.wa.gov/portals/1/Documents/2900/tbiguideline.pdf

4. If the pediatric patient does not need a head CT, observation is recommended for the patient's current condition. Use the Appendicitis Diagnosis Guideline for assessing possible appendicitis and the use of ultrasound for diagnosis for children 2 years of age and older.



Use templates to assist with standardizing the reporting of the imaging findings.
Worksheet for ultrasound technologists to use when performing the exam.

RLQ Ultrasound Technologist Worksheet: Appendicitis

Patient's Name: ______________________ History: ______________________
MRN: ______________________ Sonographer: ______________________
Date: ______________________ Radiologist: ______________________

VISUALIZATION			
Entire Appendix Seen?	Yes	Partial	Not Visualized
Appendix seen originating from cecum?	Yes		No

FINDINGS			
	Origin	Mid	Tip
Maximum Outer Diameter (mm)			
Wall Thickness (mm)			
Measured Transverse or Longitudinal?			

Echogenic Fat	Absent	Present	Unable to Assess
Mural Hyperemia	Absent	Present	Unable to Assess
Compressibility	Absent	Present	Unable to Assess
Fecalith	Absent	Present	Unable to Assess
Internal Appendiceal Contents	Hypoechoic	Echogenic	Unable to Assess
Complex Free Fluid	Absent	Present	Unable to Assess
Simple Free Fluid	Absent	Present	Unable to Assess
Lymphadenopathy (>8mm short axis)	Absent	Present	Unable to Assess
Tenderness on Exam	Absent	Present	Unable to Assess

ADDITIONAL FINDINGS / SONOGRAPHER COMMENTS (Consider: Bowel, Bladder, Gallbladder, Right Kidney, Intussusception, Ovarian Pathology)

**This worksheet is intended for sonographer to radiologist communication only and should not be used in place of the radiologist's final interpretation in the report.*

Adapted from the Safe and Sound Collaborative

Template Designed for Radiologists – RLQ Radiologist Template

EXAMINATION: [*Abdominal ultrasound, limited*].

DATE: [*Exam Date*]

COMPARISON: [Prior Date]

TECHNIQUE: Grayscale sonographic image acquisition of the right lower abdomen was performed.

CLINICAL HISTORY: [Clinical History]

FINDINGS:

Visualization: [The appendix is visualized in its entirety./The appendix is partially visualized./The appendix is not visualized.] [The appendix is seen originating from the cecum./The appendix is not seen originating from the cecum.]

Maximum Outer Diameter (in mm, normal <7mm)

- Origin: [Size]
- Midportion: [Size]
- Tip: [Size]

Wall Thickness (in mm, normal <1.7mm): Measures up to [thickness/location] mm seen in the [transverse/longitudinal plane].

Echogenic Fat: [Absent/Present/Unable to Assess]

Appendiceal Mural Hyperemia**:** [Absent/Present/Unable to Assess]

Compressibility: [Absent/Present/Unable to Assess]

Fecalith: [Absent/Present/Unable to Assess]

Internal Appendiceal Contents: [Hypoechoic/Echogenic/Unable to Assess]

Fluid Collection: [Collection: Absent /Present]

Enlarged Mesenteric Lymph Nodes (>8mm short axis): [Absent/Present/Unable to Assess]

Tenderness on Exam: [Absent/Present]

Template Designed for Radiologists (continued)

IMPRESSION:

- Normal Appendix

- Appendix not visualized or partially visualized without secondary signs of appendicitis. Based on the absence of inflammatory signs there is low likelihood of acute appendicitis.

- Appendix not visualized or partially visualized with secondary signs of appendicitis. Based on the presence of [x|y|z] there is a high likelihood of acute appendicitis. Recommend surgical consultation for further evaluation.

- Acute appendicitis

[Primary diagnostic features indicating appendicitis include the following: appendiceal diameter 7 mm or greater, wall thickness 1.7 mm or greater and lack of compressibility.

Secondary diagnostic features shown to be associated with appendicitis include the following: periappendiceal echogenic fat, appendiceal wall hyperemia, fecalith, complex fluid and/or fluid collection.

Additional findings documented in this report that are non-specific and may be seen in a number of conditions including the normal child are mesenteric lymph nodes and simple free fluid.

References

1. Goldin A, Khanna P, Thapa M, et al. “Revised ultrasound criteria for appendicitis in children improve diagnostic accuracy.” *Pediatr Radiol* 41(8): (2011): 993-999.

2. Wiersma F, Toorenvliet B, Bloem J,et al. “US examination of the appendix in children with suspected appendicitis: the additional value of secondary signs.” *Eur Radiol* 19(2): (2009): 455-461.]

Adapted from Safe and Sound Collaborative

Step 3: Educate and Collaborate

Imaging Service Staff

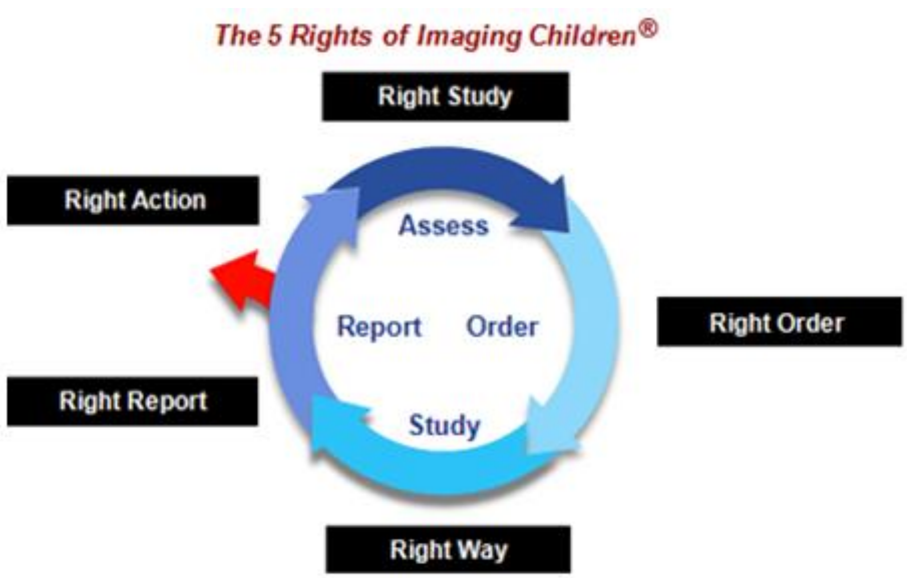
- Collaborate with radiology staff, radiologists, physicists, ordering physicians and ED staff
- Use or develop an educational algorithm on dose reduction processes
- Use or develop and educational tool for size- or age-specific pediatric protocols
- Use or develop education for Dose Monitoring and using an audit tool for CT exams
- CT specific education (see Appendix A)

Ordering Physicians

- Identify champions for dose optimization and radiation safety
- Educate on PECARN algorithm and the process of using observation for minor head trauma
- Educate on ordering single phase CT studies instead of dual phase studies
- Educate on using ultrasound as the first choice of imaging procedures instead of CT for suspected appendicitis

Board Members and Executive Leaders

- Educate board members and executive leaders
- Educate on the 5 rights of Imaging Children®
- Educate on measures and implementation strategies



Step 4: Evaluate Success

Collect and Report Data

Hospitals collect numerators and denominators and report monthly to Washington State Hospital Association. Understand your individual facility benchmarks, establish goals and compare to national resources for DLP dose ranges and PECARN utilization.

Data Collection and Reporting – Phase 1 Revised

- Optimize radiation dose for pediatric head computed tomography (CT)
- Submit data to WSHA through QBS 2.0

Refine Procedures and Protocols – From Step 2

- Review current radiation doses for pediatric head computed tomography (CT)
- Enroll in a national registry for dose reporting
- Utilize the ACR Sample Pediatric Reports for dose comparison and adjustments
- Comply with NEMA-XR-29 national standards for CT Scanners
- Review XR-29 embedded pediatric procolos for imaging (see Appendix B)
- Refine pediatric protocols to further optimize dose, as necessary (see Appendix B)
- Review options for iterative reconstruction (see Appendix A)
- Review options for tube current modulation and patient centering (see Appendix A)
- Consider aligning pediatric protocols with the five age ranges noted in the American College of Radiology Dose Index Registry for comparison[xi] (see Appendix B)
  - Ages 0 to 2
  - Ages 3 to 6
  - Ages 7 to 10
  - Ages 11 to 14
  - Ages 15 to 18

Data Collection and Reporting – Phase 2 Revised

- Support provider awareness and utilization of the Pediatric Emergency Care Applied Research Network (PECARN) pediatric head injury/trauma algorithms noted in Step 2
- Audit charts for evidence of or reference to elements of PECARN in decision making

Reference Available Resources

See Step 2 and Appendices A and B.

Continue to Share Data

PECARN utilization and DLP data should be shared monthly with the steering team and with forums at all levels from the board to nursing units.

Step 5: Hardwire Excellence

Collect Staff Input to Evaluate Need for Changes in Processes

Leaders can support staff by rounding during implementation to find out what is working and what is not. Collecting and acting on staff input to evolve the process ensures quality care to the patient and efficient flow for staff. Developing or utilizing standardized forms assists with maintaining or updating processes.

Celebrate Successes

In addition to celebrating successes at the staff and department level, share your stories with the Washington State Hospital Association. Sharing best practices across our state benefits all patients in the region, as well as nationally since we collaborate with other hospitals associations and networks.

Spread to Other Imaging Studies

After the initial implementation determine the next priority studies to target for ongoing improvement work. Ensure all pediatric patients can benefit from this strategy.

We recognize that this process represents a lot of new material. Many of the questions you have can be answered in the toolkit. You can send additional questions by email to safeimaging@wsha.org.

Appendix A

Choosing Wisely

Choosing Wisely[vi] is an initiative of the American Board of Internal Medicine (ABIM) Foundation to help physicians and patients engage in conversations to reduce overuse of tests and procedures, and support physician efforts to help patients make smart and effective care choices. Choosing Wisely is working to spark conversations between providers and patients to ensure the right care is delivered at the right time. Providers and patients should discuss evidence-based recommendations together in order to make wise decisions about the most appropriate care based on their individual situation.

Choosing Wisely has created a list of important information that physicians and patients should discuss. These include the following recommendations for imaging:

Don't do computed tomography (CT) for the evaluation of suspected appendicitis in children until after an ultrasound has been considered as an option. Although CT is accurate in the evaluation of suspected appendicitis in the pediatric population, ultrasound is nearly as good in experienced hands. Since ultrasound will reduce radiation exposure, ultrasound is the preferred initial consideration for imaging examination in children. If the results of the ultrasound exam are equivocal, it may be followed by CT. This approach is cost-effective, reduces potential radiation risks and has excellent accuracy, with reported sensitivity and specificity of 94 percent[vii].

http://www.choosingwisely.org/doctor-patient-lists/american-college-of-radiology/

A child's brain tissue is more sensitive to ionizing radiation. Computed tomography (CT) scans are not necessary in the immediate evaluation of minor head injuries; clinical observation/Pediatric Emergency Care Applied Research Network (PECARN) criteria should be used to determine whether imaging is indicated. Minor head injuries occur commonly in children and adolescents. Approximately 50 percent of children who visit hospital emergency departments with a head injury are given a CT scan, many of which may be unnecessary. Unnecessary exposure to x-rays poses considerable danger to children including increasing the lifetime risk of cancer because a child's brain tissue is more sensitive to ionizing radiation. Unnecessary CT scans impose undue costs to the health care system. Clinical observation prior to CT decision-making for children with minor head injuries is an effective approach.

http://www.choosingwisely.org/doctor-patient-lists/american-academy-of-pediatrics/

Image Gently

The mission of the Alliance for Radiation Safety in Pediatric Imaging (the Image Gently[vii] Alliance) is to improve the safety and effectiveness of the imaging care of children worldwide. This is achieved through increased awareness, education and advocacy on the need for the appropriate examination and amount of radiation dose when imaging children. The ultimate goal of the Alliance is to change practice locally to improve the health and safety of the child.

CT Education and Resource Information

Iterative Reconstruction

Iterative Reconstruction is a statistical algorithm used to reduce noise in CT images. CT images obtained with a lower doses of radiation will result in an image that is noisy (grainy). Iterative reconstruction applies the algorithm and removes image noise resulting in optimal image quality. This process can sometimes result in using 60 percent less radiation for the same level of quality in the CT images. The iterative process is performed differently across the various CT vendors. Newer generation CT scanners come equipped with iterative reconstruction hardware and software.Certain older generation CT scanners can obtain iterative reconstruction capabilities from the CT vendor or third party manufactures. CT personnel should work closely with their radiologist to establish protocols using iterative reconstruction for leading edge CT practice.

Tube Current Modulation

Tube current modulation is used to automatically adjust the amount of radiation delivered to a specific body region to assure optimal image quality at the lowest radiation dose. Tube current modulation allows the CT scanner to adapt the tube current (mA) to the thickness of a body region. If set appropriately, the tube current will automatically increase with more attenuation (thicker body region) and decrease with less attenuation (thinner body region). Decreasing tube current without changing any other technical factors will reduce radiation exposure to the patient. Most newer generation CT scanners have the capability to modulate tube current. CT technologists should be aware of the tube current modulation capabilities and apply modulation to all CT protocols under the guidance of a supervising radiologist and/or physicist. To obtain the lowest dose of radiation with appropriate image quality, the patient must be centered on the CT scanner. Tube current modulation varies by vendor and appropriate scanner specific education is necessary prior to applying modulation techniques.

Patient Centering & Tube Current Modulation

Patient centering is crucial to assure that tube current modulation adjusts appropriately during the length of the CT scan. Inappropriate centering of the patient can affect the overall image quality of the examination. Facilities need to ensure staff understand the importance of centering the patient which will yield optimal image quality with the least amount of radiation being used. If the patient is not centered appropriately, a patient could receive too much radiation or too little radiation for the examination.

- If the patient is not centered correctly side to side, the patient will receive too little radiation and there will be excessive noise in the images.
- If the patient is centered too high on the CT table, the tube current modulation will use too much radiation and over expose the patient.
- If the patient is centered too low on the CT table, the tube current modulation will use a setting that results in too little radiation being delivered and image quality with increased noise. The patient must be centered with the body part that is being imaged centered on the CT table. Use the vendor specific positioning lights to help guide patient positioning so the body part to be scanned is centered in the x and y axis of the CT opening (bore of the gantry).

Appendix B

1) **Preparation for Building Protocols**
   a) Obtain initial vendor apps Training
   b) Set dose watch parameters
   c) Remove 140 kVp protocols
   d) Enable dose modulation
   e) Build protocols
   f) Label protocols “adult” and “pediatric”

2) **Basic Protocol Build Process**
   a) Set upper and lower limits (dose modulation)
   b) Reduce rotation speed
   c) Is this a body scan?
      i) If yes – Increase Pitch for body scans
      ii) If no – proceed to 2d (below)
   d) Enable iterative construction
   e) Create written protocol
   f) Consider aligning pediatric protocols with the five age ranges noted in the American College of Radiology Dose Index Registry for comparison
      - Ages 0 to 2
      - Ages 3 to 6
      - Ages 7 to 10
      - Ages 11 to 14
      - Ages 15 to 18

3) **Optimize and/or Reduce Radiation Dose**
   a) Increase noise index by 5% increments
   b) Perform phantom test to ensure quality
   c) Begin performing studies
   d) Radiologist provides feedback on study quality
   e) Is the image of sufficient quality to be readble by the Radiologist?
      i) If yes, go back to A
      ii) If no, adjust to previous setting

4) **Update Protocols**
   a) Review DLP for age/size appropriateness
   b) Review image for clinical viability and discuss options for iterative reconstruction
   c) Include Radiologic Technologist in updates
   d) Radiologist reviews and approves final protocol
   e) Update written protocols
   f) Educate on and implement new or refined protocols

5) Audit Protocols

a) Establish a process for identifying outliers
b) Establish a multidisciplinary team to review outliers
c) Audit a specified number of pediatric CTs at least monthly
d) Follow instructions outlined on the Audit Tool below
e) Post Quality Assurance data for monthly review

Audit Tool Requirements & Instructions

Requirements:

- The audit tool is a guideline for auditing CT pediatric exams, but is highly recommended for use in the auditing process for adult examinations.
- At minimum, perform monthly audits of CT examinations.
- Use the auditing tool for standardization of the auditing process.
- Perform the appropriate number of pediatric CT audits:
  - Less than 30 pediatric patients per month, review 100% of the exams
  - 30-100 pediatric CT patients per month, review 30 patient exams
  - 101-500 pediatric CT patients per month, review 50 patient exams
  - More than 500 pediatric patients per month, review 70 patient exams

Instructions for using the audit tool:

1. Fill in the date of the examination.
2. Identify the specific CT scanner.
3. Document the MRN # or the Accession # of the examination. Be consistent with method.
4. Document the age of the patient in years (ages 0 to 17).
5. Document the initials of the performing technologist.
6. Choose the appropriate CT exam from the list. If the exam is not listed, choose other and document the exact exam in the comment field.
7. Yes or No – document if a radiologist protocolled the examination.
8. Yes or No – document if a pediatric protocol was used.
9. Choose acceptable or unacceptable for the image quality of the examination. Image quality can be considered unacceptable if inappropriate scan parameters were used and the dose was high.
10. Document if the positioning was acceptable or unacceptable for the examination.
11. Document if the appropriate anatomy was covered for the specified examination.
12. Yes or No – document if a series was repeated, but not specified in the exam protocol.
13. Document the mAs for the examination.
14. Document the kVp for the examination.
15. Document the Noise Index used for the examination**.**
16. Document the total DLP for the examination.
17. Document any pertinent information about the exam, if necessary (include any failure information).
18. Document the initials of the individual auditing the examination.

References

[i] Duncan, James. "Benefits of Eliminating Overuse in Medical Imaging*." Institute for Healthcare Improvement.* 3 Feb. (2014). Web. 20 May 2014. http://www.ihi.org/communities/blogs/_layouts/ihi/community/blog/itemview.aspx?List=0f316db6-7f8a-430f-a63a-ed7602d1366a&ID=23

[ii] Lee, Jaimy. "Watching Out for the Youngest Patients*."* *Modern Healthcare*. 2 Nov. (2013). Web. 20 May 2014. http://www.modernhealthcare.com/article/20131102/MAGAZINE/311029965

[iii] Hricak, Hedvig., Brenner, David J., et al. "Managing Radiation Use in Medical Imaging: A Multifaceted Challenge." *Radiology*. March (2011). Web. 30 September 2017. http://pubs.rsna.org/doi/full/10.1148/radiol.10101157

[iv] UC Davis Health System. "Reducing Unnecessary and High-dose Pediatric CT Scans Could Cut Associated Cancers by 62%." 10 June (2013). Web. 30 September 2017. https://www.ucdmc.ucdavis.edu/publish/news/newsroom/7854

[v] National Cancer Institute. "Radiation Risks and Pediatric Computed Tomography (CT): A Guide for Health Care Providers." 7 June (2012). Web. 20 May 2014. https://www.cancer.gov/about-cancer/causes-prevention/risk/radiation/pediatric-ct-scans

[vi] American Board of Internal Medicine Foundation. "Choosing Wisely." June (2014). Web. 30 September 2017. http://www.choosingwisely.org/

[vii] Image Gently. "The Alliance for Radiation Safety in Pediatric Imaging." June (2014). Web. 30 September 2017. http://www.imagegently.org/

[viii] American College of Radiology. "Dose Index Registry." September (2017). Web. 30 September 2017. https://www.acr.org/Quality-Safety/National-Radiology-Data-Registry/Dose-Index-Registry

[ix] Kuppermann, N. (2009) Identifying children with very low risk of ciTBI. *Lancet*; 374; 1160-1170. Web. 30 September 2017. https://www.ncbi.nlm.nih.gov/m/pubmed/19758692/

[x] Radiology Support Communication and Alignment Network. (2017). September (2017). Web. 30 September 2017. https://rscan.org/

[xi] American College of Radiology. "National Radiology Data Registry Semiannual Report-Pediatric Jul-Dec 2016." December (2016). Web. 30 September 2017. https://www.acr.org/~/media/ACR/Documents/PDF/QualitySafety/NRDR/DIR/DIRPedSampleReport.pdf?db=web