

Practice Quality Improvement (PQI) Project in Neuroradiology
In partial fulfillment of the American Board of Radiology Maintenance of Certification

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**AMERICAN SOCIETY OF NEURORADIOLOGY (ASNR) and AMERICAN SOCIETY OF
PEDIATRIC NEURORADIOLOGY (ASPNR)**

Title: Reducing radiation exposure in children for evaluation of ventriculomegaly

Purpose: The aim of this practice quality improvement (PQI) project is to reduce radiation exposure in the pediatric population with long-term ventriculostomy placement from repeated CT scanning for evaluation of ventricular size. (Note: The pediatric population is defined as children less than 18 years old for the purpose of this study. However, a subgroup of the population may be used if the scanning protocols are different depending on patient's age or weight criteria.)

Overview: There is rapidly growing public concern regarding the increasing radiation exposure from medical imaging and the consequent cancer risks in adults and particularly children [1]. Although, the risk for any individual person is not large, the increasing exposure to radiation in the population may be a public health issue in the future [2]. Overall, radiation exposure from medical imaging has dramatically increased in the past two decades. Computed tomography (CT) has had the greatest contribution to overall exposure. It is estimated that more than 62 million CT scans per year are currently obtained in the United States, including at least 4 million for children [3]. The growth of CT use in children has been driven primarily by the decrease in the time needed to perform a scan obviating the need for anesthesia to prevent motion [4]. There are known deleterious effects on the brain from radiation exposure, including cancer induction and neuronal injury related to cognitive decline. Epidemiologic studies support an associated increased risk of cancer for adults and children at organ doses corresponding to a common CT study with a dose in the range of 30 to 90 mSv [5]. Children are at greatest risk from a given dose of radiation both because they are inherently more radiosensitive and because they have more remaining years of life during which a radiation-induced cancer could develop.

This PQI project is focused on the pediatric population status post ventriculostomy procedure or catheter placement. This specific population is particularly vulnerable to higher cumulative radiation exposure due to the long-term need for repeated assessment of the ventriculostomy catheter and ventricular size in both symptomatic and asymptomatic patients. The following are three main methods that can be used to decrease the radiation exposure from medical imaging: (1) Reduce the CT-related radiation dose to individual patients by using automatic exposure control (AEC), revised protocols with low-dose parameters (reduced kVp and mAs, thick collimation), and limited CT coverage of the brain to the supratentorial region. (2) Replace CT scanning with other non-radiation modalities with comparable diagnostic accuracy and less patient risks, such as ultrasound or magnetic resonance imaging (MRI) with limited sequences (referred to as pediatric quick brain MRI). (3) Eliminate unnecessary or additional CT scanning by considering medical justification in

accordance with the ACR appropriateness criteria and assessment of the diagnostic benefits/risks involved for individual patients.

This PQI template is focused on reducing the radiation exposure by utilizing low-dose parameters in the scanning technique in this patient population. Developing low-dose CT protocols in children are discussed with citations for reference. The steps required for fulfillment of this template as individual or group projects are provided below. This PQI template fulfills the following ABR requirements for Neuroradiologists:

- (a) relevant to patient care
- (b) relevant to the diplomate's practice
- (c) has clearly defined metrics or measurable endpoints
- (d) incorporates an action plan for improvement and re-measurement to document improvement in quality

In this PQI template, the diplomate is expected to review head CT exams of pediatric patients with long-term ventriculostomy placement from his/her clinical practice. After reviewing the CT exams and completing the data collection worksheet for the metric described, the diplomate must evaluate his/her baseline performance. If improvement is needed, then a plan is implemented into his/her clinical practice. Suggestions of action plans for improvement are provided in the description below. Following a specified time period, then re-measurement is performed to document/evaluate improvement. If optimal performance is obtained in that metric, then the diplomate may decide to re-measure for another cycle in order to assess consistent optimal performance, monitor adequate performance of the improvement plan, or select a different metric for the next improvement cycle.

Competencies addressed: Patient care, Practice-based learning, Systems-based practice

The following information outlines the steps for participation in this PQI template. An individual diplomate or group participation is acceptable. The following provisions apply to group participation only:

1. A single diplomate from the group is designated as the Project Leader. The Project Leader is responsible for organizing meetings and record keeping.
2. Each participating diplomate's name and contact information must be recorded by the Project Leader. Each diplomate participating and completing the project will receive individual PQI credit from the ABR.
3. Enrollment for individuals in a group is open until the first data collection is started. Once data collection begins, then enrollment into the group will be closed and no other diplomates are able to participate.

4. Group participation and credit requires at least three meetings with documented attendance and minutes. Attendance is mandatory for each participant.
5. There is no minimum or maximum number of diplomates required to participate in a group project. However, the total number of cases for review should represent a minimum of 5 cases per diplomate. Overall, the minimum number of cases for review in this PQI project is set at 20 for collection of each data set in the baseline and re-measurement analysis.

THE FOLLOWING STEPS SHOULD BE UNDERTAKEN TO COMPLETE THIS PROJECT:

Step 1 – PROJECT ORGANIZATION and EDUCATION. The project description, data collection worksheets and educational materials are available on the website (www.asnr.org) for members. For group projects, meeting #1 will consist of review of the project details, timeline and educational materials.

Step 2 – ENROLLMENT. Each participant's name, institution, contact information and membership status is recorded by the Project Leader. Enrollment for individuals in a group is open until the first data collection is started. Once data collection begins, then enrollment into the group will be closed and no other diplomates are able to participate.

Step 3 – CASE SELECTION. Select 20 cases of head CT of pediatric patients with ventriculostomy catheter placement or post-operative ventriculostomy procedure. The cases must be sequentially performed over a specified time period or randomly selected. A member of the department not participating in the project, such as the CT supervisor, manager or technologist should select the cases to minimize selection bias. (Note: A subgroup of the population may be further defined if the scanning protocols are different depending on the patient's age or weight criteria.)

Step 4 – BASELINE DATA COLLECTION. The diplomate or group performs a retrospective review of each case and evaluates the case in accordance with the metric and data collection worksheet described below. For group projects, baseline data collection may be performed with all participants together or each participant may contribute data from a subset of cases. There is a minimum requirement of at least 5 cases per diplomate to contribute to the PQI project.

Metric: Record the dose length product (DLP) for each series scanned for each patient. (Note: Confirm with the manufacturer that the dose length product represents the dose for the series based on pediatric phantoms.) The effective dose is estimated from the DLP by multiplying with the body part-specific conversion factor [5]. The following are normalized values of effective dose per DLP for the head region according to patient age [6].

Patient age years	Effective dose per DLP mSv (mGy cm) ⁻¹
0	0.011
1	0.0067
5	0.0040
10	0.0032
Adult	0.0021

All data normalized to CTDI_w in the standard head CT dosimetry phantom.

Data collection worksheet: Record the DLP as a continuous variable from the CT scanner screen save. Record the appropriate conversion factor according to patient's age using the above table. Estimated effective dose is calculated from the simple equation: DLP x conversion factor. The following is a data collection worksheet that may be used:

Patients	Age years	DLP	Effective dose per DLP mSv (mGy cm) ⁻¹	Estimated Effective Dose mSv
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				

Calculation of the mean and median for the age, DLP and estimated effective dose are performed for the sample population in the project. Range is also determined as a measure of variability. The Project Leader is responsible for collecting the data from each participant and performing calculations.

Step 5 – FEEDBACK. The Project Leader is responsible for generating a report to the group with a summary document of the data submitted. A review of the data is performed to identify if the metric measured is in an unacceptable range and/or needs improvement. Analysis of the root cause for the performance is considered. For group projects, meeting #2 will review and discuss this feedback and determine the most appropriate action plan and its implementation.

Step 6 – ACTION PLAN. After completing the root cause analysis, the diplomate(s) must develop an appropriate action plan for improvement. Suggestions are provided below as some examples that may be applicable. In accordance with the ALARA principle (as low as reasonably achievable), the following action plans will reduce radiation exposure:

(1) Low-dose CT protocol - The Society for Pediatric Radiology (SPR) provides guidance in developing CT protocols for children or verifying that current protocols are appropriate in their web-based document, *How to Develop CT Protocols in Children* [7]. Instructions on lowering mAs in CT protocols for children and recommendations for applying appropriate reduction factors are provided according to the patient's age. Examples of low-dose head CT protocols for children with ventriculoperitoneal shunts are published in the literature with a discussion on image quality in monitoring hydrocephalus [8,9].

(2) Automatic exposure control (AEC) - an option available on many CT scanners to automatically adjust the in-slice exposure factors depending on patient thickness and attenuation of tissues within the slice.

(3) Limited CT – utilizes selected scanning of only the supratentorial region to assess ventricular size.

Alternative action plans: (1) If performance is considered optimal at this step, then the diplomate(s) must select the same metric for re-measurement to assure stable performance and proceed to Step 8 for re-measurement of data. (2) If performance is consistently optimal for several cycles of re-measurement, then the diplomate(s) can monitor performance of the implemented improvement plan. Please refer to Step 12 for monitoring performance. (3) The diplomate or group may choose to close the project at this time because improvement isn't needed or simply choose to no longer participate. *(IMPORTANT NOTE: If the diplomate or group close the project at this time, this project does not satisfy the PQI requirement. The project must include 6 months of measurement, feedback, implementation of improvement, repeat 6 months of measurement, second feedback, then closure to receive PQI credit from the ABR.)*

Step 7 – RE-MEASUREMENT. After a period of time allowing for improvement, which should be at least 3 months, but no longer than within the three year cycle, the diplomate(s) must select 20 cases that were performed after implementation of the improvement plan and review them with the same metric as described in the baseline data collection in Step 4. The Project Leader is responsible for collecting data and performing calculations.

Step 8 – FEEDBACK FOR REFLECTION AND GOAL ASSESSMENT. The Project Leader will send a report to the group with a summary document of the re-measurement data submitted. A review of the second data is performed to identify progress and improvement. For group projects, meeting #3 will review and discuss feedback and determine the most appropriate next steps. Comparison of the mean/median estimated effective dose and range are performed for the baseline data and re-measurement data. The goal is to achieve 60% or greater radiation dose reduction using the new improvement plan. Prior publications in the literature demonstrate overall dose reductions of 63% and

70% using low-dose head CT protocols for children with ventriculoperitoneal shunts for monitoring hydrocephalus [8,9].

Step 9 – DECISION POINT. Continue with this project OR select a new project. The following decisions are suggested: (1) If the goal was not achieved as described in Step 8, then continuation of the project at Step 6 for another cycle using a modified or new action plan is recommended. (2) If the goal of the project is achieved, then re-measurement of data is recommended in another cycle to demonstrate stable performance. (3) If stable performance is documented, then monitoring optimal performance is recommended as the next step in the PQI process. Please refer to Step 12 for monitoring performance. (4) The diplomate or group may choose to close the project at this time because improvement isn't needed or simply choose to no longer participate. (IMPORTANT NOTE: The diplomate and group will receive full PQI credit at this point from the ABR.)

Step 10 - REGISTRATION/ATTESTATION. Proceed to the ABR website and attest to completion of the PQI project in your ABR personal database, in accordance with instructions on the ABR website.

Step 11 – DOCUMENTATION. Maintain a record of this project in your personal or office files, as your participation in this project may be subject to a random ABR audit of your MOC Part IV activities. If you are audited, you may be asked to produce source data. Importantly, although the ASNR and ASPNR have developed this template for your use, you are advised that the ABR does not maintain data on your project. This is your responsibility. Each participant in a group will need to keep a copy of the meeting minutes (including attendance) and copies of the feedback reports provided by the Project Leader.

Step 12 – MONITORING PERFORMANCE.

Metric : Record the frequency that the new revised protocol was performed in the improvement plan. This metric may be applied as an assessment tool to demonstrate continuous acceptable performance or improvement in performance of new established programs. Evaluation of the program is performed on a short-interval basis to monitor acceptable performance status.

Data collection: At pre-determined short interval periods (eg. monthly or quarterly basis), review of 20 head CT performed on pediatric patients with ventriculostomy is assessed for compliance with the new program using the following data collection worksheet and scoring system:

Patients	Age (years)	NEW protocol performed (yes/no)	Explanations	Score
1				
2				
3				
4				
5				
6				

7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				

<u>Score</u>	<u>Protocol</u>
0	Yes, protocol performed correctly
1	No, protocol NOT performed correctly (Explanations provided below)
1a	Wrong scanning parameters used (kVp, mAs, pitch)
1b	Inappropriate scanning field (extend beyond foramen magnum to vertex)
1c	Too many series performed
1d	Radiologist protocol error
1e	Appropriate resources not available to follow protocol
1f	Other

Goal: 100% compliance with the new protocol is consistently maintained. Improvement in compliance rate compared to a prior cycle in the project may also be set as a goal.

Step 14a – BASELINE DATA COLLECTION. The diplomate or group performs a retrospective review of each case and evaluates the case in accordance with the metric and data collection worksheet described above. For group projects, baseline data collection may be performed with all participants together or each participant may contribute data from a subset of cases. There is a minimum requirement of at least 5 cases per diplomate to contribute to the PQI project. The Project Leader is responsible for collecting data from each participant and performing calculations.

Step 14b – FEEDBACK FOR REFLECTION AND GOAL ASSESSMENT. The Project Leader will send a report to the group with a summary document of the data submitted and also educational materials. A review of the data is performed to identify progress and improvement. For group projects, meeting #4 will review and discuss this feedback and determine the most appropriate next steps. Analysis of the root cause for the performance is considered. Consultation with departmental and institutional resources may be helpful in this process.

Step 14c – ACTION PLAN. After completing the root cause analysis, the diplomate or group must develop an appropriate action plan for improvement. Suggestions are provided below as some examples that may be applicable.

(1) Increase departmental support in implementing the new protocol for CT imaging of children with ventriculostomy procedures. Radiologists, CT technologists, nurses and referring physicians should be recruited for their support in reducing radiation exposure to pediatric patients. All physicians are expected to maintain a commitment to life-long learning and self-assessment in order to continuously improve the quality of their practices and continue their professional development [10,11]. The ABR guidelines state that every diplomate must select a project that potentially can improve the quality of the diplomate’s practice and enhance the quality of care [12]. In addition, CT technologists’ responsibilities also include participation in the department’s quality assessment and improvement plan according to the Practice Standards for Medical Imaging and Radiation Therapy [13]. Participation in this project entails an evaluation of the diplomate(s) practice performance linked to a process of continuing quality improvement.

(2) Improve education of Radiologists, CT technologists, nurses and referring physicians using didactic and training modules to remain updated on the current pediatric protocols and using appropriate scanning parameters in this patient population. A brief discussion on the importance in reducing radiation exposure in the pediatric population may also be included. This method can be performed as an in-service presentation, electronic on-line course or paper format in an educational brochure.

After selection of an action plan, please continue with Step 7 in the cycle for re-measurement of data.

Alternative action plans: (1) If performance is considered optimal at this step, then the diplomate(s) must select the same metric for re-measurement to assure stable performance and proceed to Step 7 for re-measurement of data. (2) The diplomate or group may choose to close the project at this time because improvement isn’t needed or simply choose to no longer participate. (**IMPORTANT NOTE:** *The diplomate and group will receive full PQI credit at this point from the ABR.*)

RECOMMENDED TIMELINE

Year	Steps Completed
1	Step 1 – Project Organization and Education Step 2 – Enrollment Step 3 – Case Selection Step 4 – Baseline Data Collection
2	Step 5 – Feedback Step 6 – Action Plan Step 7 – Re-measurement Step 8 – Feedback for Reflection and Goal Assessment
3	Step 9 – Decision Point Step 10 – Registration/Attestation Step 11 – Documentation
4 – 10	Step 12 – Monitoring Performance or Initiate New Project

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