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JSM Clinical and Medical Imaging: Cases and Reviews

Case Report

A Low Radiation Computed Tomography Protocol for Monitoring a Triple-Compartment Hydrocephalus

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Submitted: 21 March 2016

Accepted: 01 August 2016

Published: 03 August 2016

Keywords

- Hydrocephalus
- Multi-Compartments
- CT
- Shunt
- Radiation

Abstract

A case of multi-compartment hydrocephalus was diagnosed by using the computed tomography (CT) technique. This hydrocephalus indicates the separate and individually progressing sequential hydrocephalus of supra-tentorial and infra-tentorial ventricles. A low radiation dose CT brain can be used rather than the conventional CT to reduce exposure to radiation doses when monitoring hydrocephalus. It demonstrated that it provides effective information for monitoring the multi-compartment hydrocephalus and also that a shunt inserted in one lateral ventricle does not drain the other ventricle; thus the patient needs separate treatment for the other compartment.

INTRODUCTION

CT imaging requires the highest radiation doses in radiology. The cumulative dose from the use of radiation in medical investigations is rising, due to increases CT use. Patients with hydrocephalus are often subjected to repeated CT imaging in order to monitor their hydrocephalus and fluid level.

Hydrocephalus arising from intra ventricular septum divisions is known as loculated hydrocephalus [1]. Many synonyms for complex hydrocephalus have been used in the empirical literature such as multi compartments or complex hydrocephalus. Compartmentalized hydrocephalus remains a challenging neurosurgical problem [2]. The investigation of multi-compartments hydrocephalus can be confirmed by applying diagnostic imaging techniques.

It is known that the diagnostic tool of choice for the management of brain tumors in general and especially for children is the MRI [3]. However, MRI investigation requires conscious sedation for child patients, which requires a protracted procedure as well as use of the MRI scanners which is a claustrophobic experience, particularly owing to the use of a long tunnel. Neuro-physicians tend to use CT investigations to evaluate shunting fluids. This is due to the availability and rapid imaging procedure but it remains a challenging neurosurgical problem [4] due to the need for a high radiation dose due to frequent imaging. The aim of this case study is to demonstrate that a low radiation CT protocol can be used to diagnose a triple-compartment hydrocephalus compared with the conventional protocol. This study is concerned with whether a low dose radiation CT protocol could provide effective information for monitoring multi-compartment hydrocephalus compared with the conventional CT protocol. CT brain demonstrates that a multi-compartment hydrocephalus with a shunt inserted in one lateral ventricle does not drain the other ventricles, thus the patient needs separate treatment for the other compartment.

CASE PRESENTATION

A seven year-old boy was received through the emergency department with recurrent vomiting, headache and increasing drowsiness. For clinical investigations, the patient has had cephalic shunt for four years; he has congenital hydrocephalus with choroid plexus papilloma left lateral ventricle. The patient was treated at a higher medical center where a venriculo-peritoneal shunt was done on the right side. A child's shunt could become infected; the patient was drowsy, obeying commands, experiencing early papilloedema, other cranial nerves normal, spastic para paresis, functioning shunt reservoir in right frontal region.

CT Imaging

After stabilizing the patient's condition, he was referred to the diagnostic imaging department for a CT scan of the brain. The imaging protocols will be discussed in detail in the Discussion section.

DISCUSSION

The brain CT scan protocol was as follows: kV: 140, mAs: 300 pitch: 1, collimation: 15 mm, and slice thickness: 3-6 mm (3 mm slices for the infra-tentorial compartment and 6 mm slices for the supra-tentorial compartment). It was decided to leave the pitch, slice thickness and collimation unaltered so as to enable comparison with previous scans using the conventional protocol (Figures 1,2). The CT scanner used was a Siemens Somatom multi-slice scanner (Siemens AG, Erlangen, Germany). Various technical modifications in CT scanners can result in substantial savings of radiation doses. Altering the tube current is a commonly adopted strategy because ionizing radiation has a direct linear relationship with tube strength (mAs), and which controls the quantity or the amount of x-ray photons produced (Figures 3a,3b). However, alterations in tube potential, which controls the quantity or the amount of x-ray photons produced (kVp), collimation (determines the nominal or effective slice thickness), pitch (a parameter used to characterize table movement relative to the collimated thickness of the fan beam), and section thickness can also contribute to dose savings [5].

Due to CT scan repetitions, it was ascertained that the lowest radiation achievable with sufficient diagnostic information was 40 mAs and 120 kV. Below these factors, the sulci were not clearly visible. All scans in this study were done for the appropriate diagnostic need of the patient only and no additional scans were performed purely for this study. Crucially, no further scans had to be conducted due to a lack of sufficient information on the low dose CT. See Table (1) for a comparison of the conventional and low radiation CT head protocols.

For calculations of radiation dose, most studies in the empirical literature use the effective dose to compare risks from radiation associated with CT scanning [6]. The effective dose is intended to provide a single-value estimate of overall stochastic risk (i.e. the total risk of cancer and genetic defects) of a given irradiation, whether received by the whole body, part of the body or one or more individual organs [7]. The unit is a milliSievert (mSv) see Table (1). The effective dose in this study was calculated using the ImPACT CT Dosimetry dose calculator (a widely used software program for calculating the effective dose) by CT Specifications [8].

For low radiation doses, accurate measurements are not easily attained and even the best studies acknowledge error. However, it is still useful as a guide. Areas of error in effective dose calculation studies can arise due to machine, operator, patient characteristics and calculation approximations [9].

Multi-compartment hydrocephalus is a recognized clinical entity [10] This entity consists of supratentorial hydrocephalus of the third and both lateral ventricles as a result of aqueduct stenosis along with an isolated large fourth ventricle which because of the

Figure 1 Non- Contrast head Computed Tomography (NCCT) Head revealed; normal right lateral ventricle with ventricular catheter in frontal horn.

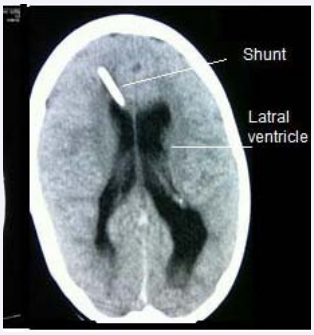

Figure 2 Grossly dilated lift lateral ventricle third ventricle in normal size and position.

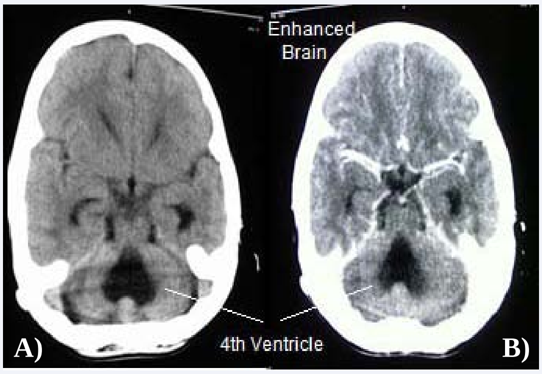

Figure 3 **A)** Grossly dilated large fourth ventricle, (Trapped fourth ventricle), in midline. **B)** Further small cisterna magna.

Figure 4 Contrast Enhanced Computed Tomography (CECT) did not reveal any papilloma in the choroids plexus of lift lateral ventricle.

Table 1: Comparing conventional and low dose computed tomography protocols.

Factors	Conventional CT Head Protocol	Low Radiation CT Head Protocol
mAs	300	
Kv	140	
Pith	1	1
Collimation	15	
Slice thickness	6 mm cerebrum; 3 mm Posterior fossa	6 mm cerebrum; 3 mm Posterior fossa
Effective radiation dose	2.2 mSv	0.30 mSv

veil over the lower end of the aqueduct and associated blockage of foramen of luschka and magendie remain dilated in spite of the lateral ventriculo-peritoneal shunt [11]. Isolated enlargement of the fourth ventricle could also arise due to the long-term intra ventricular shunt, micro hemorrhages or low grade ventriculitis (Figure 4). Most cases of isolated segmental ventricular dilatation are related to ependymal inflammation associated with the indwelling ventricular catheter [12]. Symptoms and signs of multiple compartment hydrocephaluses occur as a result of varying degrees of compression. CNS complaints have been mistakenly diagnosed as in this case due to the supratentorial shunt disorder but careful evaluation should help to differentiate the problem [13]. All of these dilated compartments of the ventricular system need to be tackled individually. The success of surgical treatment depends on early diagnosis. The major challenge in multi compartmental hydrocephalus is to promptly recognise the complicating part of the hydrocephalus in patients with a shunt already functioning for supratentorial hydrocephalus [14]. In triple compartment hydrocephalus, a shunt inserted in one lateral ventricle (compartment) does not drain the other ventricles, thus the patient needs separate treatment for all three compartments [15].

CONCLUSION

A low dose CT scan protocol can be applied for diagnosing the hydrocephalus with a shunt in order to reduce unnecessary radiation rather than the conventional CT technique. Moreover, this was debated by modifying CT imaging parameters.

In the short-term, it is hoped that this case study will allow the use of low radiation CT parameters for monitoring hydrocephalus and related shunt. Clinically, this case exhibited that the multi-compartment hydrocephalus with a shunt inserted in a single lateral ventricle does not drain the other ventricles; hence each compartment requires a separate treatment.

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Cite this article

Alrwaili AN (2016) A Low Radiation Computed Tomography Protocol for Monitoring a Triple-Compartment Hydrocephalus. JSM Clin Med Imaging Cases Rev 1(1): 1003.