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Surveillance of infection associated with external ventricular drains: proposed methodology and results from a pilot study

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SUMMARY

Background: The insertion of external ventricular drains (EVDs) is necessary in some neurosurgical patients, but increases the risk of meningitis/ventriculitis. While there are well-recognized risk factors, the proportion of patients who develop meningitis/ventriculitis varies partly due to differences in definitions. A multi-disciplinary working group was established to agree definitions for EVD-associated meningitis/ventriculitis, and a surveillance system was piloted in four centres in the UK and Ireland.

Methods: Definitions were agreed based on those published previously and on clinical and microbiological criteria. An agreed dataset was developed to monitor patients after the insertion of an EVD and until the EVD was removed and the microbial aetiology was recorded.

Findings: Four neurosurgical centres participated, with 61–564 patients surveyed in each unit. The vast majority of drains were cranial. Intracranial haemorrhage was the most common indication for the EVD insertion. Between 6% and 35% of EVDs were inserted by consultants rather than junior doctors. The proportion of patients who developed meningitis/ventriculitis varied from 3% to 18% and from 4.8 to 12.7/1000 EVD-days. Coagulase-negative staphylococci were the most common microbial causes.

Conclusions: Routine and ongoing monitoring of patients with an EVD *in situ* to detect meningitis/ventriculitis presents logistical difficulties, and few units do so. This pilot study suggests that a national system of surveillance with agreed definitions and a methodology

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to enable unit-to-unit comparisons of EVD meningitis/ventriculitis is both necessary and feasible. This will, in turn, inform quality improvement processes leading to the minimization of infection.

Introduction

Patients undergoing neurosurgery are at increased risk of healthcare-associated infections (HCAIs). In the 2006 four-country prevalence survey of HCAIs, the prevalence rate in neurosurgery was 10.5%.[1] Incidence studies of neurosurgical units in Italy and Germany found that meningitis occurred in 4—8% of patients.[2,3] Postoperative meningitis/ventriculitis is a particular risk when an external ventricular drain (EVD) is inserted to monitor or control intracranial pressure.

A Medline literature search of ventriculitis/meningitis found that the rate of infection varied from 5% to 20%.[4] This wide variation may relate to the diagnostic criteria used. The risk factors identified included: duration of EVD; frequency of EVD manipulations; presence of intraventricular haemorrhage; and surgical technique used in inserting the device (the rate is lower when the device is tunnelled under the skin after exit from the cranium with distal skin puncture).[4] A retrospective cohort study using data from national surveillance in The Netherlands was used to develop prediction models that would assist in the detection of EVD-related meningitis.[5] Observed and predicted rates of infection were compared and the correlation was approximately 95%. Predictive factors for meningitis were abnormalities of the cerebrospinal fluid (CSF; e.g. raised white cell count), type of drain (ventricular or lumbar), and whether or not admission to an intensive care unit was required.[5]

Various criteria are used to diagnose meningitis/ventriculitis, some of which are exclusively microbiologically based (e.g. positive CSF culture), while others include microbiological findings, clinical presenting features and CSF abnormalities (e.g. increased CSF leukocyte count).[6] For surveillance purposes, it is preferable not to include a decision to treat with antibiotics because meningitis/ventriculitis may be mimicked by other conditions (e.g. intracranial haemorrhage), and antibiotics may be given to treat infection at other sites in a seriously ill patient. A further challenge for surveillance is selecting an appropriate denominator. Rates of infection are often calculated as numbers of patients with infection as a percentage of the total with an EVD. However, the use of denominators that account for the duration of the device are preferable (e.g. per 1000 EVD-days) as the risk of infection increases the longer the EVD is in situ.

Most causes of meningitis/ventriculitis are skin organisms; staphylococci (i.e. *Staphylococcus epidermidis* and *Staphylococcus aureus*) account for nearly 80%, followed by a variety of other organisms that include aerobic Gram-negative bacilli (AGNB) and, occasionally, fungi.[4] The isolation of *S. epidermidis* or other coagulase-negative staphylococci (CoNS) in the CSF needs to be interpreted with caution as this may represent contamination and can result in over-treatment.

In the absence of a national surveillance system of neurosurgical meningitis/ventricultis, a multi-disciplinary working party was established and funded under the auspices of the Healthcare Infection Society to agree definitions, identify the challenges in establishing a national surveillance system, and highlight preventative strategies. The purpose was to test the feasibility and practicality of a surveillance system to measure the incidence of ventriculitis associated with EVDs in neurosurgical patients. This article reports the agreed definitions and their use, a suggested dataset, and the results from a multi-centre pilot surveillance system in the UK and Ireland.

Methods

While the risk of infection with an EVD includes the insertion procedure, the device also provides an external route by which pathogens may gain access to the ventricles. The risk of infection is therefore likely to be influenced by the length of time that the device remains *in situ*, and the extent to which it is manipulated during this period, rather than the insertion procedure specifically. The methodology developed for this surveillance was therefore based on the methods used for central vascular catheters, rather than surgical site infection, and used device-days as a primary denominator to calculate the risk of EVD-associated ventriculitis.[7,8] The data captured were used to calculate the following metrics:

- rate of ventriculitis per 1000 EVD-days; and
- percentage of patients with EVDs who developed ventriculitis.

The number of EVD-days was determined as the number of days between device insertion and device removal for all patients included in the surveillance.

A patient-level surveillance method was employed, and each patient with a newly inserted drain was followed prospectively to identify whether or not ventriculitis occurred.[9] Table I indicates the variables captured for each patient included in the surveillance. Surveillance was continued until the device was removed or the patient was transferred/discharged or died.

The case definitions for EVD-associated ventriculitis were developed after much discussion and consideration of existing published definitions, and were adapted from Horan *et al.* to distinguish probable from definite meningitis/ventriculitis (Table II).[10] Cases of ventriculitis clearly associated with a recently removed EVD were included, and if an EVD was replaced, this was considered as a new device and a new surveillance record was commenced. A new episode of infection was recorded if a different micro-organism was isolated from the CSF, or the same micro-organism was isolated from the CSF but at least four weeks had elapsed from a previous infection and there was evidence that the first infection had resolved.[11] When definite or probable venticulitis met the definition, the causative pathogen was recorded.