The Changing Microbiological Pattern in Patients with Confirmed Bacterial Meningitis after Post-craniotomy Surgery

Změna mikrobiologickýho vzorku u pacientů s potvrzenou bakteriální meningitidou po postkraniotomiální operaci

The authors declare they have no potential conflicts of interest concerning drugs, products, or services used in the study.
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Abstract
Post-craniotomy meningitis (PCM) is an important challenge in neurosurgery. In this study, PCM was diagnosed in 22 of the 4,392 post-craniotomy patients between January 1, 2008 and December 31, 2012. There were significant statistical differences between the seven patients with *Acinetobacter baumannii* meningitis and 15 patients with non-*Acinetobacter baumannii* meningitis with respect to the history traumatic head injury (OR = 5.873, 95% CI 1.575–17.511; p = 0.004) and infected sites other than the central nervous system (OR = 0.872, 95% CI 0.665–1.621; p = 0.003). We provide the most up-to-date insight to physicians on the changing pattern of infectious agents in PCM.

Souhrn
Meningitida po kraniotomii(PCM) představuje důležitou výzvu v neurochirurgii. Tato práce popisuje diagnostikovanou PCM u 22 z 4 392 pacientů s provedenou kraniotomií v intervalu mezi 1. lednem 2008 a 31. prosincem 2012. U sedmi pacientů s meningitidou způsobenou bakterií *Acinetobacter baumannii* a u 15 pacientů s neprokázanou *Acinetobacter baumannii* meningitidou byly signifikantní rozdíly ve výskytu traumatu hlavy (OR = 5,873, 95% CI 1,575–17,511; p = 0,004), a lokalizací infekce mimo centrální nervový systém (OR = 0,872, 95% CI 0,665–1,621; p = 0,003). Naše sdělení nabízí lékařům aktuální pohled na měnící se vzorec infekčních agens u PCM.

Key words
meningitis – neurosurgery – *Acinetobacter baumannii* – *Staphylococcus aureus* – head trauma

Klíčová slova
meningitida – neurochirurgie – *Acinetobacter baumannii* – *Staphylococcus aureus* – poranění hlavy

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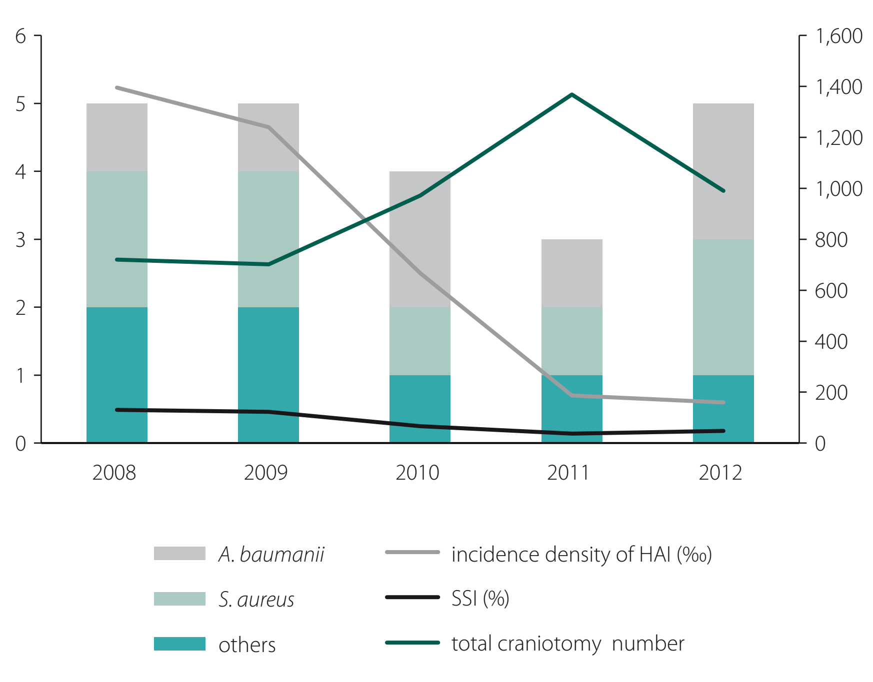
Introduction

Post-craniotomy meningitis (PCM) results in severe morbidity and mortality [1,2]. The rates of PCM have been reported to vary from 0.3 to 10%, and *Staphylococcus aureus* (*S. aureus*) is the major pathogen [2,3]. Some studies revealed that the rate of PCM due to *Acinetobacter baumannii* complex (*A. baumannii*) is increasing [1,4–6], and *A. baumannii* meningitis (ABM) causes high mortality rates [5]. In addition, the rate of PCM due to *A. baumannii* has become accretive from China, Iran and Turkey [1,4–6]. The limited epidemiological data can be perplexing for physicians, in both making accurate diagnosis and choosing effective antibiotics, hence an urgent clinical need was behind the motivation to perform this study to determine the current pattern of infectious agents of PCM in Changhua Christian Hospital (CCH).



Graph 1. The correlation among healthcare associated infection, surgical site infection, and total craniotomy number and total post-craniotomy meningitis during the study period was shown.

Others included *P. aeruginosa* in 2 patients, *K. pneumoniae* in 2 patients, *E. cloacae* in one patient, *E. coli* in 1 patient, and *E. faecalis* in 1 patient.

HAI – healthcare associated infection, SSI – surgical site infection.

Observation

The study was approved by the ethics committee of CCH (CCH IRB No. 131118). CCH is a 1,800-bed tertiary referral medical center, and more than 1,500 craniotomies are performed in CCH every year. This retrospective study included 22 patients who developed post-neurosurgical meningitis among the 4,392 patients who underwent craniotomy procedures between January 1, 2008 and December 31, 2012. Cases of post-craniotomy meningitis were identified from microbiological databases and medical records according to the International Classification of Diseases, ninth edition, clinical modifications (ICD-9-CM) at CCH in central Taiwan. The diagnosis of meningitis was based on the inclusion criteria and included both significant clinical evidence and microbiological confirmation. The definition of surgical site infection (SSI) is according to CDC/NHSN surveillance definitions [7]. The Vitek-2 System (BioMerieux, Marcy l'Etoile, France) was used to identify the phenotype of isolates. SPSS version 21.0 for Windows (SPSS Inc., Chicago, IL, USA) were used statistical analysis.

During the study period, PCM was diagnosed in 22 of the 4,392 operated patients. The prevalence of PCM in CCHS was 134.4 ± ± 76.8 per 100,000 patient-years during the study period. The incidence of PCM was 0.5% among the 4,392 operated patients in CCH. The five-year longitudinal analysis of healthcare-associated infections (HAI), SSI, and total number of craniotomies and total number of PCMs during the study period is shown in Graph 1. The key risk factors among the 4,392 patients who underwent post-craniotomy operation and

Tab. 1. Demography and clinical characteristics between *A. baumannii* and non-*A. baumannii* patients who happened post-craniotomy meningitis.

Parameters		Total (n = 22)	Meningitis		p[1]	OR (95% CI)	p[2]
			Ab (n = 7)	non-Ab (n = 15)			
infected sites other than the CNS	yes	14 (63.6)	1 (14.3)	13 (86.7)	0.002	0.665–1.621	0.003
	no	8 (36.4)	6 (84.7)	2 (13.3)			
head trauma	yes	6 (27.3)	5 (71.4)	1 (6.7)	0.004	5.873 (1.575–17.511)	0.004
	no	16 (72.7)	2 (28.6)	14 (93.3)			

[1] p value between those with meningitis and those without meningitis.
[2] p value for odds ratio (OR).
Data presents with number with percentage (parenthesis), n (%). The non-Ab group included *S. aureus* in 8 patients, *P. aeruginosa* in 2 patients, *K. pneumoniae* in 2 patients, *E. cloacae* in 1 patient, *E. coli* in one patient, and *E. faecalis* in 1 patient.
Ab – *Acinetobacter baumannii* complex, CNS – central nerve system.

Tab. 2. Demography and clinical characteristics of seven patients who happened post-craniotomy *A. baumannii* meningitis.

Patient characteristics	Patient 1	Patient 2	Patient 3	Patient 4	Patient 5	Patient 6	Patient 7
age (years)/sex/FATD (days)	41/M/8	32/M/30	65/M/8	56/M/10	41/M/5	38/F/12	75/F/2
Neurosurgical diagnosis							
head traumatic injury/intracerebral hemorrhage/ /intracerebral tumor	Y/N/N	Y/N/N	N/Y/N	Y/N/N	Y/N/N	N/N/Y	Y/N/N
co-morbidity							
diabetes mellitus/malignancy/coronary artery disease	N/N/N	N/N/N	Y/N/N	Y/N/N	N/N/N	N/N/N	Y/N/N
other source of *Acinetobacter*	blood	no	tracheal	tracheal	tracheal	N	N
Risk Factors							
emergency procedure/CSF leak/preoperative use of corticoids/prophylactic antibiotics before operation	Y/Y/N/N	N/N/N/Y	Y/Y/N/N	Y/Y/N/N	N/N/Y/N	Y/Y/N/N	Y/Y/N/Y
tracheal intubation/tracheotomy/mechanical ventilation	Y/N/Y	Y/N/Y	Y/N/Y	Y/N/Y	N/NY	Y/N/Y	Y/Y/Y
external ventricular drain/central venous satheters insertion/drain placement > 72 hours	Y/Y/N	N/N/N	Y/N/N	Y/Y/N	Y/N/N	Y/N/Y	Y/Y/Y
surgery duration (h) > 4.5/length of preop stay > 2 days/ /ICU admission	N/N/Y	Y/N/N	N/N/Y	N/N/Y	N/N/N	N/N/Y	Y/Y/Y
urinary catheterization/on NG tube/repeat operations	Y/Y/N	N/Y/N	Y/Y/N	Y/Y/N	N/N/N	Y/Y/N	Y/Y/Y
head trauma/hydrocephalus/use of perioperative antibiotics	Y/N/N	Y/N/Y	N/N/N	Y/N/N	Y/N/N	N/N/N	Y/Y/Y
American Society of Anesthesiologists score > 2/NNIS > 2/ /concurrent infection	Y/N/Y	N/N/N	N/N/Y	Y/N/Y	N/N/N	N/N/Y	Y/Y/Y
Susceptibility to antimicrobials							
meropenem/imipenem/piperacillin/tazobactam	R/R/R	S/S/S	S/R/R	R/R/R	S/S/S	R/R/R	R/R/R
amikacin/gentamicin/cefepime	S/S/R	S/S/S	R/R/R	R/R/R	S/S/S	R/R/R	R/R/R
ceftazidime/cefotaxime/ciprofloxacin	R/R/R	S/S/S	R/R/R	R/R/R	S/S/S	R/R/R	R/R/S
colistin/tigecycline	ND/ND	ND/ND	S/S	S/S	S/ND	S/S	S/ND
definitive therapy (specified)	IMP + CL	CTX + CL	CTX + CL	IMP + CL	MRP + CL	MRP + CL	IMP + CL
appropriate definitive therapy/FDTET (days)/DOEA (days)	Y/1/16	Y/5/14	Y/1/28	Y/5/15	Y/2/28	Y/3/17	Y/5/7
mortality	Y	Y	N	Y	N	Y	Y

CL – colistin, CSF – cerebrospinal fluid, CTX – ceftriaxone, DOEA – duration of effective antibiotics, F – female, FATD – from admission to diagnosis, FDTET – from diagnosis to effective treatment, IMP – imipenem-cilstatin, M – male, MRP – meropenem, N – no, ND – no available data, NNIS – National Nosocomial Infections Surveillance, R – resistant, S – susceptible, Y – yes.

in whom PCM occurred included older age (15/1,821), emergency procedure (16/2,524), CSF leakage (15/1,822), external ventricular drainage (12/1,256), intensive care unit admission (11/1,160), drain placement duration more than 72 hours (13/993), surgery duration more than 4.5 hours (6/312), repeated operations (7/565), head trauma (6/351). The pathogens isolated from the CSF were *S. aureus* in 8 (36.4%), *A. baumannii in* 7 (31.8%), *P. aeruginosa* in 2 (9.1%), K. pneumoniae in 2 (9.1%) , *E. cloacae* in 1 (4.5%), *E. coli* in 1 (4.5%), and *E. faecalis* in 1 (4.5%). Of the 22 patients with PCM, 14 (63.6%) had at least one concurrent HAI, and the distribution of these HAI events was SSI in 15 (68.2%), pneumonia in 4 (28.6%), bacteremia in 4 (28.6%), urinary tract infection in 2 (14.3%), and central venous catheter-related infection in 1 (7.1%). Of the 22 patients with PCM, 6 (27.3%) died. There were no significant statistical differences between patients with ABM and non-ABM (Tab. 1), except for head traumatic injury (OR = 5.873, 95% CI 1.575–17.511; p = 0.004), and infected sites other than the central nervous system (CNS) (OR= 0.872, 95% CI = 0.665–1.621; p = 0.003). In this study, we disclosed that patients after traumatic head injury had higher risk of ABM (Graph 1). The clinical information of ABM is listed in Tab. 2.

Discussion

This study showed that ABM emerged in post-traumatic head injury patients with PCM. Many studies showed that non-fermentative gram-negative bacteria (GNB), most commonly *Acinetobacter spp.*, have become important in recent years [4,8,9].

We conducted an evidence-based literature review because ABM has been rarely suggested as a cause of CNS infection [10–14]. Among the 22 PCM patients, PCM was caused by *A. baumannii* in 5 of 6 patients with traumatic head injury and in 2 of 16 patients without traumatic head injury. Among the 22 PCM patients, PCM was caused by *A. baumannii* in 6 of 8 patients with only one CNS infection source. *A. baumannii* and *S. aureus* were the most commonly isolated agents in PCM and this is in line with the suggested global emergence and increase of *A. baumannii* colonization and infection, resulting from skin or wound colonization, invasive procedures, sourced from a head traumatic wound or nostrils, and some kind of predominant cluster. In our study, *S. aureus* was still the most common pathogen in patients with PCM but we emphasize that physicians should also concentrate on *A. baumannii* when treating PCM patients.

There were no significant statistical differences between meningitis group and non-meningitis group in key risk factors. However, 5 (71.4%) of 7 ABM had a history of traumatic head injury and they died. Our results are similar to those of Baltas's report that showed 6 of 12 infectious agents being GNB among 860 patients who developed complications after traumatic injury [9,10].We identified eight post--craniotomy *S. aureus* meningitis and seven post-craniotomy ABMs with 6 of them suffering from traumatic head injury. Hence, we assume that patients after traumatic head injury undergoing craniotomy easily acquire *A. baumannii* and *S. aureus* infection.

In conclusion, we found a high rate of PCM due to *A. baumannii* and *S. aureus* among patients with traumatic head injury. The changing pattern of infectious agents in PCM over time suggests the need for further studies to provide the most up-to-date insight to physicians.

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