

Infections in Neurosurgical Intensive Care Patients: A 3-Year Study in a Tertiary Health Care Center, North India

Deepa Chaturvedi¹ Pragnya P. Jena² Bansidhar Tarai² Kavita Sandhu¹

¹Department of Neuroanaesthesia, Max Super Speciality Hospital, New Delhi, India

²Department of Microbiology, Max Super Speciality Hospital, New Delhi, India

Address for correspondence Bansidhar Tarai, MD, Institute of Lab Medicine, Max Super Speciality Hospital, Saket, New Delhi 110017, India (e-mail: bansiss@gmail.com).

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Abstract

Background In the neurosurgical patient community, infection rate depends on the severity of neurological injuries at the time of presentation, which is measured by the Glasgow coma score (GCS). In addition, associated comorbidities; exposure to invasive devices such as endotracheal tube, central venous catheters, and urinary catheters; and neuroscience-specific devices, such as ventricular/lumbar catheters, increase chances of infection. We share our experience from a dedicated neurosurgical intensive care unit (NSICU) of a super speciality tertiary care hospital in north India.

Patients and Methods This is a 3-year retrospective and observational study from January 2014 to December 2016. Total 2,608 patients were admitted to NSICU during this period; 229 patients were included whose cultures were collected after 48 hours of admission and were positive. We have analyzed patient's risk factors, length of stay (LOS), outcome, organism details, and those health care-associated infections (HAI) that fulfilled the CDC (Centers for Disease Control and Prevention) criteria.

Results Out of 2,608 patients admitted, 229 were culture positive after 48 hours of admission and 53 developed HAIs (53/2,608 [2.03%]). Male-to-female ratio was 2:1. One hundred three patients had a low GCS (5–8) and 126 had a high GCS (9–15). Average LOS in ICU was 6 days, and mortality was 17.4% (40/229). A total of 57 laboratory-confirmed positive cultures were identified in 53 patients. This included 35 from urine, 15 from blood, 2 from surgical wound, and 1 from respiratory tract. Among the HAI, the rate of ventilator-associated pneumonia (VAP) was 0.22, central line-associated bloodstream infection (CLABSI) 3.43, catheter-associated urinary tract infection (CAUTI) 5.93, and surgical site infection (SSI) 0.9%.

Conclusion Neurosurgical patients are particularly vulnerable to infection because of the formidable nature of their illness, frequency of associated trauma, and presence of invasive devices. In our study, lower rate of HAIs was observed because we have a dedicated NSICU, strict infection control practices, an appropriate antimicrobial stewardship program, and early shifting of neurosurgical patients to an appropriately staffed high-dependency unit/ward.

Keywords

- ▶ infections
- ▶ neurosurgical intensive care unit
- ▶ risk factors
- ▶ lumbar and ventricular drain
- ▶ Glasgow coma score

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Introduction

Health care-associated infections (HAIs) are most commonly associated with invasive medical devices or surgical procedures. Millions of patients are affected by HAIs worldwide every year, leading to significant morbidity and mortality as well as financial loss for health systems.¹ The HAIs burden is also significantly higher in low- and middle-income nations as compared with high-income countries, especially in patients admitted to intensive care units. Urinary tract infection is the most frequent HAI in high-income countries, whereas surgical site infection (SSI) is at the forefront in the low-income group, affecting up to one-third of operated patients. In high-income countries, approximately 30% of patients in intensive care units (ICUs) are affected by at least one HAI.²

In the neurosurgical and neurocritical patient population, HAI rate depends on the severity of neurological illness at presentation and the exposure to invasive devices such as endotracheal tube (ET), central venous catheters (CVCs), and urinary catheters, in addition to neuroscience specific devices, such as ventricular or lumbar catheters. Although common causes of infection in a neurosurgical ICU (NSICU) patient are the same as those for any critically ill patient, specific considerations should be made for infections because of depressed level of consciousness and surgical opening of the cranial vault.³ Most of the time, clinical signs and symptoms of neurological patients with infectious fever and noninfectious fever markedly overlap.⁴

A majority of neurosurgical patients requiring ICU admission comprise those who have head injuries, subarachnoid hemorrhages, or complications of neurosurgical procedures. Only a minority will be admitted with preexisting intracranial or spinal infections, whereas majority will develop infections while they are in the ICU.⁵ High rate of infections are associated with long ICU stay, polytrauma, indiscriminate use of antibiotics, and lumbar puncture (LP)/Ommaya drain.

Good practices for infection prevention and control measures reduce the opportunities for resistant pathogens to spread in health care facilities.⁶ Additionally, timely microbiological surveillance and assessment of antimicrobial resistance are important for dealing with HAIs. There is paucity of quality data in literature about the HAI rates in NSICUs in India. We are sharing our experience from a dedicated NSICU of a tertiary care center in north India.

Ethical Statement

This is a retrospective collection of data, which did not entail any direct contact with the patient; hence, the consent was waived. This study was approved by scientific and ethics committee of our hospital.

Study Design and Patient Population

This is retrospective and observational study in NSICU. It was conducted in a 506-bedded tertiary care hospital with a 13-bedded dedicated NSICU. Data were analyzed over a span of 3 years from January 2014 to December 2016.

Patients and Methods

Annual admission of patients in our NSICU is approximately 800 to 900. During this study period, 2,608 patients were admitted into the NSICU directly from home, road traffic accident (RTA) via triage, respiratory ward, medical ward, nephrology ward, and also transferred from other hospital. Out of 2,608 patients, culture was received in 229 patients after 48 hours of admission and was positive. Patients whose initial cultures were positive within 48 hours of ICU admission were not included. Status of the patient was assessed using the Glasgow coma score (GCS) and other medical conditions on admission. Laboratory results and specific clinical indicators were used to categorize infections as per CDC (Centers for Disease Control and Prevention) nosocomial infection surveillance definitions.⁷ Infection control bundles were followed and analyzed on monthly basis.

Sample Collection and Processing

Samples were collected aseptically whenever there was a suspicion of infections and as a routine protocol if patients transferred from other hospitals. Samples included urine, blood, and endotracheal secretion, in addition to cerebrospinal fluid, wound aspirate, bronchoalveolar lavage fluid, pleural fluid when indicated, and stool for *Clostridium difficile* polymerase chain reaction (PCR) in specific cases. Swab for methicillin-resistant *Staphylococcus aureus* (MRSA) was taken only if the patient came from another hospital.

All samples were transported to the clinical microbiology laboratory for immediate processing. Blood was cultured in the BacT Alert 3D system (Biomérieux, France). The other samples were processed according to established standardized protocol and current Clinical and Laboratory Standards Institute (CLSI) guideline.⁸

Isolates were identified to the species level and antimicrobial susceptibility testing was done using Vitek Excel (Biomérieux, France). Quality control was done using American Type Culture Collection (ATCC) strain.

Statistical Analysis

Data were analyzed using spread sheet. Statistics were analyzed based on percentage, mean, and median values or interquartile ranges (IQRs), as appropriate. *p* Values < 0.05 were considered statistically significant. Univariate analysis was employed to determine the contribution of clinical variables to the prediction of acquisition of infections in the ICU. Also, we calculated the odds ratios of risk factors for developing HAIs in ICU.

Results

Out of 2,608 patients, culture collected from 229 patients after 48 hours of admission was positive. Out of 229 patients, male-to-female ratio was 2:1 with an age range of 1 to 94 years, and length of stay (LOS) in the ICU ranged from 2 to 60 days (►Table 1). The most common diagnosis on admission was intracranial hemorrhage 62 (27%), followed by space-occupying lesion (SOL) 53 (23%), spine involvement 46 (20%), stroke 23 (10%), RTA 20 (8%), and subarachnoid hemorrhage 17 (7%) (►Fig. 1). Patients admitted with low

Table 1 Baseline demographic and clinical characteristics of patients (number, %, mean, IQR)

| Variables | n = 229 | Percentage (%) | Mean | Median (IQR) |
|----------------------------------------------------|---------|----------------|--------|--------------|
| Gender | | | | |
| Female | 73 | 31.9 | | |
| Male | 156 | 68.1 | | |
| Age (y) | | | 52 y | |
| 1–14 | 6 | 2.6 | | |
| 15–60 | 131 | 57.2 | | |
| 61–90 | 92 | 40.2 | | |
| GCS | | | | |
| Low GCS (3–8) | 103 | 44.9 | | |
| High GCS (9–15) | 126 | 55.1 | | |
| Length of ICU stay (day) | | | 6 days | 5 (8–3) |
| 2–7 | 173 | 75.5 | | |
| 8–60 | 56 | 24.5 | | |
| Locations before ICU admissions | | | | |
| From other hospitals | 19 | 8.2 | | |
| Home | 94 | 41.2 | | |
| RTA | 25 | 10.9 | | |
| Triage | 63 | 27.5 | | |
| Transferred from various wards within the hospital | 28 | 12.2 | | |
| Mortality rate | 40 | 17.4 | | |

Abbreviations: GCS, Glasgow coma score; IQR, interquartile range; RTA, road traffic accident.

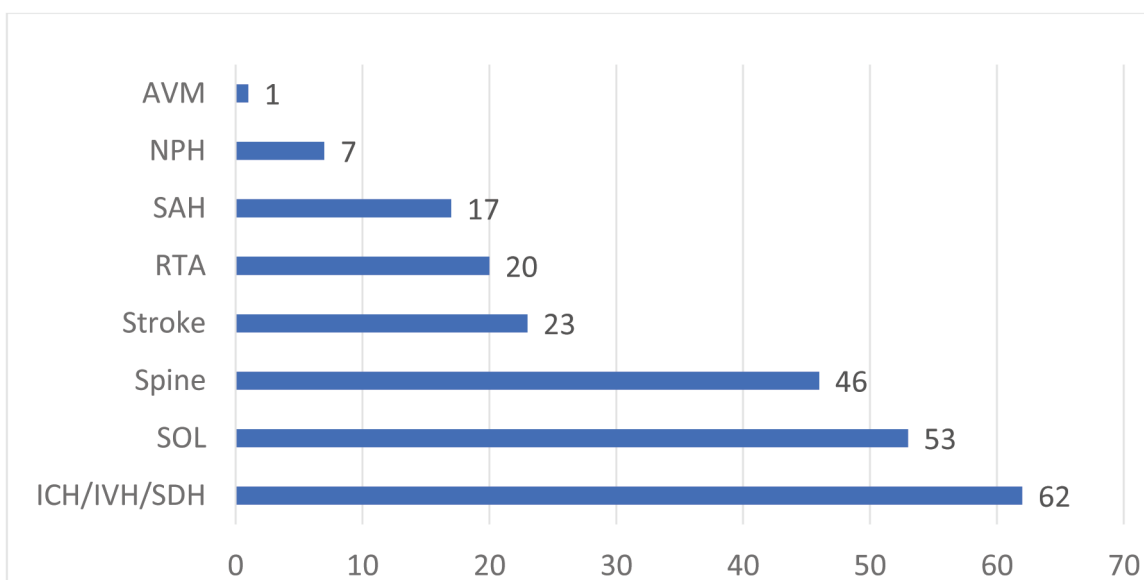


Fig. 1 Distribution of cases admitted in neurosurgical ICU (n = 229). AVM, arteriovenous malformation; ICH, intracerebral hemorrhage; IVH, intraventricular hemorrhage; NPH, normal-pressure hydrocephalus; RTA, road traffic accident; SAH, subarachnoid hemorrhage; SDH, subdural hemorrhage; SOL, space-occupying lesion.

GCS were 103 (44.9%), whereas 126 (55.1%) patients had high GCS. For outcome analysis, patients were distributed into two subgroups according to survival status (died or transferred out to HDU/room/ward). In the present study, mortality rate was 17.4% (40/229) (► **Table 2**).

Out of 229 patients, 167 were intubated, 115 were urinary catheterized, and 164 were on CVC in the internal jugular vein and subclavian vein. Patients transferred from other hospitals, RTAs via triage were 107 (46.6%), patients admitted directly from home were 94 (41.2%), and 28 (12.2%) were transferred from various wards and ICUs within hospitals. Out of 229 culture-positive patients, 53 cases developed HAIs (53/2,608 [2.03%]) (► **Table 3**). Among 53 HAIs, 29 developed early-onset (between 3 and 7 days on ICU admission), whereas 24 had late-onset infections. A total of 57 laboratory-confirmed positive cultures were identified in 53 patients. The most common infection was urinary tract infections in 35 patients, followed by bloodstream infection (BSI) in 15 cases. One patient had two episodes of catheter-associated urinary tract infection (CAUTI) and another patient had two episodes of BSI. A total of 2 cases of skin-soft tissue infections (SSI), and only one patient had pneumonia.

Microbiological Distribution of Pathogens Identified

Thirteen different species of pathogenic microorganisms were identified out of 57 isolates (► **Fig. 2**). Overall, the most common organism causing HAI was *Klebsiella pneumoniae* (24%), followed by *Escherichia coli* (22%). The percentage of multi-drug-resistant (MDR) organism among gram-negative bacilli was 26%. In infected patients, we followed culture-directed sensitivity. No case of *C. difficile* infection and MRSA was noted.

Univariate Analysis of Risk Factors of HAIs in the NSICU

Using univariate analysis, statistically significant association of risk factors in development of HAIs are antibiotics use before ICU admission ($p < 0.001$, odds ratio [OR] = 6.775), presence of devices such as ET ($p < 0.001$, OR = 7.450), urinary catheter ($p = 0.002$, OR = 2.386), central line ($p < 0.001$, OR = 8.022), location before admission ($p = 0.038$, OR = 2.063),

ICU stay > 7 days ($p = 0.003$, OR = 2.724), and malignancy ($p = 0.001$, OR = 8.775) (► **Table 4**).

Discussion

In the present study, the incidence of infection was 2.03%, which is similar to study by Dettenkofer et al⁹ but less as compared with Orsi et al.¹⁰ The study by Kumar et al showed that prevalence rate of infection in neurosurgical patients was high (18%) when it was not a dedicated NSICU.¹¹ In our study, CAUTI are most prevalent followed by BSIs, whereas in other studies, the most common infection was respiratory tract, followed by infections of the urinary tract.^{9,10,12} We observed only a single case of ventilator-associated pneumonia (VAP) as compared with other studies. The VAP patient was operated upon in other hospital for head injury and admitted to our ICU with bilateral lower-zone consolidation. We have a low VAP rate because of the practice of closed suction and placement of subglottic ETs for all ventilated patients. Additionally, on initiation of ventilation, sterilized expiratory cassette is attached on ventilator and again changing the sterilized expiratory cassette every week for long-term ventilated patients.

Catheter-associated urinary tract infections were most common in the study by Chacon et al,¹³ which was similar to our study. We observed that CAUTI rate was 5.93, which was similar to a study by Orsi et al and Abulhasan et al in NSICUs.^{10,14} The reason for relatively higher CAUTI in our study was that neurosurgical patients required prolonged and multiple urinary catheterization. Our central line-associated bloodstream infection (CLABSI) rate was 3.43, which was much lower than that reported by Orsi et al.¹⁰ In our study, CVC lines were changed whenever there was a clinical indication, but in the study by Orsi et al, CVC line days were not mentioned. Most common organisms were gram-negative bacilli in our study, and this was similar to other studies.^{9,11,13,15,16} Our study shows *K. pneumoniae* as the most common organism in overall HAIs, whereas *E. coli* was most common in CAUTI. A significant finding was that no *C. difficile* infection and MRSA were observed in our study. This could be because of HAI bundles we followed for prevention of infection.

Our study showed significant association of risk factors in development of HAIs. Indiscriminate use of antibiotics in ICU, prolonged use of devices, such as ET, urinary catheter, and central venous line, and condition of patients at the time of admission, ICU stay > 7 days, and malignancy played a major role in the development of infection in general ICU.^{17,18} Thus patients, regardless of type of ICU, have similar rate

Table 2 Percentage of mortality in relation to GCS score

| GCS | Number of deaths (n = 40/229) | Percentage (17.4%) |
|------|----------------------------------|--------------------|
| 3–8 | 29 | 12.6 |
| 9–15 | 11 | 4.8 |

Abbreviation: GCS, Glasgow coma score.

Table 3 Distribution of health care-associated infections (HAIs)^{1,7}

| Type of infection | No. of infections | Device days | HAI calculation | HAI rate |
|-------------------|-------------------|----------------------|------------------------------------------------|----------|
| VAP | 1 | 4,350 | No. of VAP/No. of ventilatory days × 1,000 | 0.22 |
| CLABSI | 15 | 4,361 | No. of CLABSI/No. of central line days × 1,000 | 3.43 |
| CAUTI | 35 | 5,895 | No. of CAUTI/No. of catheter days × 1,000 | 5.93 |
| SSI | 2 | 215 (No. of surgery) | No. of SSI/Total no. of surgery × 100 | 0.9% |

Abbreviations: CAUTI, catheter-associated urinary tract infection; CLABSI, central line-associated bloodstream infection; HAI, health care-associated infection; SSI, surgical site infection; VAP, ventilator-associated pneumonia.

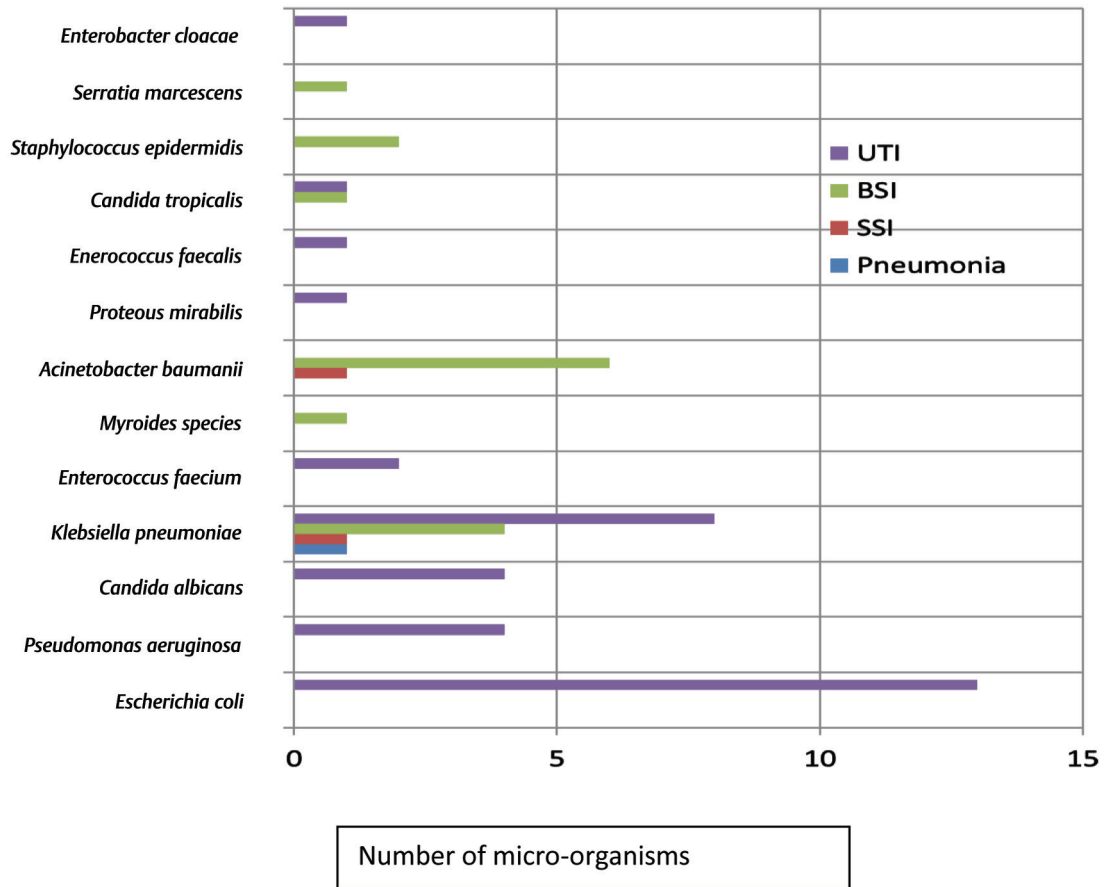


Fig. 2 Distribution of microorganisms isolated in various infections ($n = 53$). BSI, bloodstream infection; SSI, surgical site infection; UTI, urinary tract infection.

of infection with the use of invasive devices. In addition, in neuro patients, other factors, such as diabetes mellitus, hypertension, malignancy, chronic renal failure, and use of steroid for reducing peritumoral edema in space-occupying lesions pre- or postoperatively, influence the incidence of HAIs. The ICU infection may be expected to escalate because of more complex neurosurgical procedures that are prolonged, thereby exposing patients to higher incidence of infection. Because infection is related to the length of ICU stay, early shifting of neurosurgical patients to an appropriately staffed high-dependency unit/ward is likely to result in reduction in the infection rate.¹¹

In the present study, mortality rate was 17.4%, which was similar to the study by Orsi et al¹⁰ and Laborde et al.¹⁵ Deaths in low GCS cases were 12.6%, whereas in high GCS these were 4.8%. We observed that mortality may not directly relate to infection but may be an attributable cause of death.

The primary role of an infection-control program is to reduce the risk of hospital-acquired infection, thereby protecting patients, health care workers, and visitors.¹⁹ Antibiotic stewardship programs aim to optimize rational antibiotic use while minimizing antibiotic resistance, thus improving patient safety. This new era in HAI epidemiology is

characterized by increasing scrutiny and regulation, and consumer demands for more transparency and accountability, along with calls for rapid reductions in HAI rates.²⁰

NSICU Protocol and Infection Control Practices Followed in Our Hospital

We give prophylactic surgical antibiotic within 60 minutes before incision: (1) injectable cefuroxime single dose in clean cases, (2) cefuroxime (24 hours) and single dose of amikacin intraoperatively in spinal surgery with implant, (3) cefuroxime with amikacin and metronidazole for 72 hours in clean cerebrospinal fluid (CSF) leak cases. Infection control bundles followed in our hospital are CDC guided. There is a provision of a separate hand rub, artificial manual breathing unit (AMBU) bag, thermometer, bed pan, deep vein thrombosis (DVT) pump, and stethoscope for each bed. We follow regular communication of intensivist and clinical microbiologist on daily basis. We have separate nurses for wound care, bedsore, and SSIs, restricted visitors/visiting hours in ICU, etc. Key concerns are proper hand hygiene, pre-surgery body wash with chlorhexidine below the neck, rational antibiotic policy, optimal device site care, maximum barrier precaution, daily review, and care.

Table 4 Univariate analysis of risk factors for neurosurgical intensive care unit-acquired infections ($n = 229$)

| Risk factors | HAI (53 patients) | Non-HAI (176 patients) | p-Value | Odds ratio |
|------------------------------------------------------------|-------------------|------------------------|---------|------------|
| Use of antibiotic before NSICU admission | | | | |
| Yes | 41 (18%) | 59 (25%) | < 0.001 | 6.775 |
| No | 12 (5.2%) | 117 (51%) | | |
| Endotracheal intubation | | | | |
| Yes | 53 (23%) | 114 (50%) | < 0.001 | 7.450 |
| No | 0 | 62 (27%) | | |
| Urinary catheterization | | | | |
| Yes | 53 (23%) | 62 (27%) | 0.002 | 2.386 |
| No | 0 | 114 (50%) | | |
| Presence of central line | | | | |
| Yes | 53 (23%) | 111 (48%) | < 0.001 | 8.022 |
| No | 0 | 65 (28%) | | |
| Location before admission | | | | |
| Within the hospital wards/other hospital/ RTA/emergency | 38 (16%) | 97 (42%) | 0.038 | 2.063 |
| Home | 15 (6%) | 79 (34%) | | |
| Age (y) | | | | |
| < 60 | 32 (14%) | 105 (45.8%) | 1.000 | 1.030 |
| > 61 | 21 (9%) | 71 (31%) | | |
| Sex | | | | |
| Male | 35 (15%) | 121 (52.8%) | 0.738 | 0.883 |
| Female | 18 (7.8%) | 55 (24%) | | |
| Malignancy | | | | |
| Yes | 7 (3%) | 3 (1%) | 0.001 | 8.775 |
| No | 46 (20%) | 173 (75%) | | |
| Length of ICU stay | | | | |
| ≥ 7 | 24 (10%) | 41 (18%) | 0.003 | 2.724 |
| < 7 | 29 (12.6%) | 135 (60%) | | |
| GCS | | | | |
| Low GCS (3–8) | 17 (7%) | 83 (36%) | 0.080 | 0.595 |
| High GCS (9–15) | 33 (14%) | 96 (42%) | | |

Abbreviations: GCS, Glasgow coma score; HAI, health care-associated infection; ICU, intensive care unit; NSICU, neurosurgical intensive care unit; RTA, road traffic accident.

Conflict of Interest

None declared.

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