Research Article

Antimicrobial stewardship in spinal cord injury: A multidisciplinary approach

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Context: In a global environment of escalating antimicrobial resistance and limited new antibiotic development, there is a desire to optimize antibiotic use across all settings to preserve options for the future. Despite this, antibiotics continue to be prescribed inappropriately in many settings. Patients with a spinal cord injury (SCI) are particularly vulnerable to receiving multiple courses of antibiotics, yet there is limited data reviewing antimicrobial stewardship (AMS) programs in this patient population.

Hypothesis: Adopting AMS rounds will reduce days of antibiotic treatment.

Intervention: We implemented a systematic bedside AMS multidisciplinary team (MDT) ward round within the SCI Unit at our hospital, where a collaborative inter-speciality and inter-professional approach was undertaken to address antibiotic prescriptions. A retrospective audit of antibiotic prescriptions was performed one month prior and one month during the intervention.

Outcome measures: An infectious disease consultant led a multidisciplinary, multispecialty ward rounding team, looking at antibiotic appropriateness and guideline compliance. The effectiveness of this intervention was assessed by retrospectively looking at antibiotic days of usage per patient day of occupancy.

Results: Antibiotic consumption significantly decreased following the AMS intervention, from 69.8 to 24.3 days on treatment per 100 patient days ($P < 0.001$). Following implementation of the ward round the proportion of therapeutic guideline compliant prescriptions significantly rose from 18% in April to 56% in August ($P < 0.001$).

Conclusions: Utilizing a collaborative inter-speciality and inter-professional AMS approach and providing face to face feedback about the appropriateness of antibiotic prescribing can help optimize antibiotic usage within a SCI unit.

Keywords: Spinal cord injury, SCI, Antimicrobial stewardship, Antibiotic resistance, Multidisciplinary team

Introduction

Antimicrobial resistance (AMR) is one of the greatest threats facing global health. By 2050 it is estimated that 2.4 million people across Europe, North America and Australia will die from resistant organisms, and their treatment will incur costs of \$3.5 billion dollars per year.¹ The significant burden of resistance arises largely from a twofold problem: owing to poor investment opportunities limited new drug development is occurring^{2,3} and the usage of antimicrobials is rising. Looking across 76 countries between 2000 and 2015, antibiotic consumption increased 65% when defined in daily doses.⁴ This increasingly toxin saturated global

environment is fueled by persistent inappropriate antibiotic use across all healthcare sectors.^{5,6}

Patients with SCI are one of the most vulnerable populations to receiving multiple courses of antibiotics, and therefore AMR. In a study observing 423 SCI patients over a 6 week period, the rate of nosocomial infection was found to be 25.8% compared to 16% across other admissions, with resistant organisms representing 11% of these infections.⁷ Factors for developing resistance in patients with SCI include frequent contact with the healthcare system, high rates of bacterial infection with multi-drug resistance organism, and increased frequency of invasive medical devices such as urinary and intravascular catheters.⁸ Respiratory tract infections represent the most common infective complication for patients with SCI during their initial hospitalization

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occurring at rates as high as 60%.⁸ Urinary tract infections and pressure ulcers serve as the most frequent causes for rehospitalization and occur with incidences of 34% and 10% respectively.⁹

Antimicrobial stewardship (AMS) studies are abundant across the health care landscape but are surprisingly scarce in patients with SCI.⁶ In a survey of 118 spinal cord injury specialists, more than half stated they had never used antibiograms to determine treatment for patients with SCI despite 95% believing this would lower resistance.¹⁰ The availability of infectious disease (ID) physicians and clinical pharmacists in hospitals has been associated with improved adherence to AMS programs.¹¹ Despite this, no work has yet been completed to investigate the impacts of a multidisciplinary team, including ID physician, clinical pharmacist and spinal physicians, involvement in treatment decisions for patients with SCI.

In Australia, guidelines have been developed for antimicrobial prescribing practices by the National Health and Medical Research Council. Whilst no section is specifically dedicated for patients with SCI, recommendations exist for invasive devices, management of multi-resistant organisms and developing AMS programs.¹² General therapeutic guidelines that address both catheter-related infections and chronic ulcers also exist, and are readily available via an electronic resource.¹³ Despite the ease of guideline access, questions remain as to how well implemented these are in practice, particularly as patients with SCI are not specifically mentioned. By introducing a weekly antimicrobial stewardship round at a single center in Sydney, we sought to investigate whether ID physician and clinical pharmacist involvement could lead to significant prescribing behavioral change in this environment.

Methods

Setting

The Prince of Wales Hospital is one of two units that provide care for patients with SCI in the state of New South Wales, Australia. The SCI unit comprises of 10 acute ward beds and 20 rehabilitation ward beds.

Intervention

We implemented a systematic weekly bedside AMS multidisciplinary team (MDT) ward round in the SCI unit in June 2018. The AMS MDT ward round included three phases. Phase one, prior to the round, the clinical pharmacist reviewed all patients' prescribed antibiotics examining indication, drug selection (including dosage, form and frequency), duration and relevant microbiology results. Phase two, antibiotic prescriptions

identified by the pharmacist were discussed with the ID physician. Phase three took place on the SCI unit with ID consultant, Clinical Pharmacist and Spinal Physicians (Spinal ward interns/residents, Spinal Registrars/Advanced Trainees and Consultant) present. During the round, opportunities were given for questions regarding current patient antibiotic management, then education about current recommendations and feedback given for prescriptions flagged by the AMS team. The three phases were conducted over approximately 45 min. The Clinical Pharmacist would be responsible for following up on recommendations made by the AMS MDT ward round.

Study design

A retrospective cohort study was conducted comparing antibiotic prescriptions in the SCI unit pre (April 2018) and post (August 2018) implementation of the AMS MDT ward round. April and August were chosen to avoid potential biases with anticipatory behaviors the month prior to implementation and to allow teams to be accustomed to the intervention.

Data collection

The electronic medical record (EMR) was reviewed for all patients who had an antibiotic prescribed during the study period. Data collected included patient age, Charlson comorbidity index (CCI),¹⁴ the presence of systemic inflammatory response syndrome (SIRS),¹⁵ indication for antibiotic, type/dose/route/duration of antibiotic(s) prescribed, and results of any cultures. The presumed indication for antibiotic prescribing was taken from the treating clinician's working diagnosis as documented in the medical record.

Inclusion/exclusion criteria

All antibiotics prescribed for patients in 30 SCI unit beds over the study period were reviewed. Entries were excluded if they were found to be charting errors or were not administered.

AMS assessment tools

Appropriateness of antibiotic prescriptions and concordance to evidence-based guidelines/expert opinion was assessed using the National Antimicrobial Prescribing Survey (NAPS) auditing tool.^{16,17} This assessed antibiotic prescriptions as either being optimal (1), adequate (2), suboptimal (3), inadequate (4) or not assessable (5). A second concordance rating system was also applied which examined adherence to either therapeutic or local guidelines. This classed prescription decisions as either therapeutic guideline compliant (1), local guideline compliant (2), noncompliant (3), a directed

therapy (4), no guidelines available (5), or not assessable (6). Spectrum of antibiotic breadth was assessed using the hospitals AMS restrictions akin to the World Health Organisations antibiotic classifications of 'Access' (green), 'Watch' (yellow) and 'Reserve' (red).¹⁸ All assessments were done in agreement by the ID consultant and clinical pharmacist on the study team.

Statistics

Most data was simple categorical and amenable to either chi-squared testing or Fisher's exact test when sample numbers were low. A Mann–Whitney test statistic was applied for the CCI and a Kruskal–Wallis test for age. Statistical analysis was conducted using R and SPSS software packages.^{19,20}

Results

In the initial retrieval for the audit 159 entries were obtained of which 25 were excluded. 134 prescribing events remained of which 88 occurred during April and 46 in August. Table 1 summarizes the patient characteristics for the two groups. The groups did not differ significantly in terms of age, sex, CCI or SIRS.

The 46 prescribing events in August post intervention translated to a decrease of 69.8 to 24.3 treatment days per 100 patient bed days ($P < 0.001$). Leading indications for commencement across both months were not significantly different ($P = 0.44$), with genitourinary infections the most common indication followed by skin and soft tissue, then respiratory infections (Table 1). Concerning antibiotic spectrum, there was a significant decrease in the use of 'Watch' class antibiotics¹⁸ (which

includes meropenem, vancomycin, 4th generation cephalosporins, fluoroquinolones and piperacillin/tazobactam) use during the intervention period ($P = 0.05$) (Table 2).

Regarding prescribing practices, following the implementation of the ward round there was a significant increase in therapeutic guideline compliant prescriptions ($P < 0.001$). During the intervention period 56% of all prescriptions were guideline concordant, compared to only 18% pre-intervention. NAPS scores failed to demonstrate a statistically significant change. Both NAPS and Guideline scores are summarized in Table 2.

Discussion

We introduced a collaborative inter-speciality and inter-professional AMS program in our SCI unit in June 2018. To our knowledge this is the first study conducted that evaluates a multidisciplinary AMS intervention in a SCI unit. We have demonstrated that a AMS MDT weekly ward round, involving a clinical pharmacist, ID physician and SCI physicians, significantly decreases total antibiotic use and increases guideline concordance. This offers a new paradigm for improving AMS in facilities that have guidelines available but face problems with adherence. In comparison to the paucity of previous work in this area, our method offers a practical and effective approach for centers that can't afford

Table 1 Baseline characteristics.

	Pre-implementation	Post-implementation	P-value
Age – median	55 [37, 63]	59 [49, 63]	0.096
Sex – <i>n</i> (%)			1.000
Male	24 (80)	15 (79)	
Female	6 (20)	4 (21)	
SIRS – <i>n</i> (%)	10 (11)	11 (24)	0.058
Charlson – <i>n</i> (%)			0.055
1	2 (7)	0 (0)	
2	8 (27)	2 (11)	
3	7 (23)	2 (11)	
4	4 (13)	6 (32)	
5	3 (17)	5 (26)	
6+	6 (20)	4 (20)	
Site – <i>n</i> (%)			0.441
Genitourinary/	34 (39)	18 (40)	
Gastrointestinal			
Skin/soft tissue	24 (27)	15 (33)	
Respiratory	11 (12)	8 (18)	
Osteomyelitis/	14 (16)	3 (7)	
hardware infection			
Other	5 (6)	1 (2)	

Table 2 Antibiotic prescribing.

	Pre-implementation	Post-implementation	P-value
Total daily doses	629	226	<0.001
Spectrum – <i>n</i> (%)			0.050
Access class	45 (51)	31 (70)	
Watch class	43 (49)	14 (30)	
Reserve class	0 (0)	0 (0)	
Guidelines – <i>n</i> (%)			
Therapeutic guidelines	16 (18)	25 (54)	<0.001
Local guidelines	1 (1)	0 (0)	1.000
Noncompliant	24 (27)	10 (22)	0.485
Directed Therapy	47 (53)	9 (20)	<0.001
Not assessable	0 (0)	2 (4)	0.120
NAPS – <i>n</i> (%)			
1: Optimal	52 (59)	31 (67)	0.347
2: Adequate	8 (9)	4 (9)	1.000
3: Suboptimal	18 (21)	4 (9)	0.081
4: Inadequate	10 (11)	6 (13)	0.776
5: Not assessable	0 (0)	1 (2)	0.343

systematic ID physician consultations for the entirety of their patients²¹ and lack a national stewardship program for reference.²²

Total daily doses (TDD) per 100 patient days in our study reduced almost two thirds following introduction of the MDT weekly ward round from 69.8 to 24.3. This is the first study we could see that demonstrated a significant decrease in antibiotic use in a SCI unit following an AMS intervention. Our data supports the findings in a retrospective cohort study in a 150 bed rehabilitation hospital in Italy where an AMS program with systematic ID physician consultation decreased total daily doses from 42 to 22 defined daily doses per 100 patient days. They also noted a significant reduction in resistance in isolated *Pseudomonas aeruginosa*, *Escherichia coli*, *Klebsiella* spp. and *Staphylococcus aureus*.²¹ Whilst resistance was not quantified in our study, it is well documented that antibiotic exposure engenders resistance.^{23–26} It is interesting to note that despite the smaller sample size, different locations and mixed acute/rehabilitation population, following the intervention there was good agreement in improvement in defined daily doses between our unit and the Italian rehabilitation facility. Our results build on findings from a survey across the American Veteran's Affairs Hospitals that both ID physician ($P = 0.03$) and clinical pharmacist ($P = 0.006$) are statistically significant factors for treatment time reduction.¹¹

Adherence to therapeutic guidelines significantly improved following the MDT ward round from 18% to 56% of all prescriptions. This is the first study to broadly assess an AMS intervention on guideline adherence by scrutinizing treatment decisions within a SCI population. Pursuing this outcome we have attempted to answer questions posed of guideline adherence by earlier work. A previous survey of spinal cord physicians revealed that up to a third either didn't know of the existence of guidelines or where to find them.¹⁰ An observation study looking at the management of bacteriuria in patients with SCI found that treatment decisions were being made on culture positivity alone and up to a third of these were contrary to guidelines.²⁷ In the general population, better guideline adherence has led to improved inpatient mortality and shorter length of stay.²⁸ Whilst work is currently underway to better understand barriers between clinicians and guideline adherence for the SCI population,²⁹ our study demonstrates this can be improved with a simple MDT ward round approach.

The reduction seen in 'Watch' and 'Reserve' antibiotics using an MDT for treatment decisions is not isolated to our study. The previously mentioned Italian

study by Tedeschi *et al.* showed statistically significant decreases in fluoroquinolone and meropenem use following the introduction of ID consultation in the facility. Both fluoroquinolones and carbapenems are broad spectrum antibiotics in the 'Watch' class used for gram negative pathogens such as *Escherichia coli*, *Klebsiella* spp., *Acinetobacter* spp., and *Pseudomonas aeruginosa*. These pathogens are the leading causes of nosocomial infections³⁰ and are associated with up to a 33% in-hospital mortality if they develop antibiotic resistance.³¹ It is therefore highly important that the use of 'Watch' class antibiotics is optimized and reserved for patients where there are no other treatment options. Whilst our study did not investigate expenditure or resistance, Tedeschi *et al.* found that extended spectrum *Pseudomonas aeruginosa* resistance fell from 55% to 12% in their spinal population with no changes in mortality or length of stay. To date no long term studies have been performed investigating mortality or expenditure outcomes of such interventions in SCI patients.

Our study has limitations in research design that need to be acknowledged. The study was retrospective, which may limit the strength of our conclusions in comparison to randomized prospective studies. However, comparison of SIRS criteria and CCI showed no significant differences in acuity or patient morbidity between the cohorts. The sample size was limited due to the small numbers in each group, but nonetheless was successful in demonstrating significant reduction in antibiotic use. Given this was a single-center study design we are limited in generalizing our results.

Conclusion

Despite the presence of increasing AMR, inappropriate prescribing of antibiotics in speciality areas such as SCI remains highly prevalent. Providing face to face feedback about the appropriateness of antibiotic prescribing can help combat AMR, treatment failure, and unnecessary adverse events due to inappropriate antibiotic prescribing. Our study demonstrated how a simple, time effective, multidisciplinary approach can lead to improved appropriateness and decreased antibiotic use in patients with SCI.

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