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Assessing Safety and Outcomes of the Atlanta Veterans Affairs Medical Center's Outpatient Parenteral Antimicrobial Program

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Assessing Safety and Outcomes of the Atlanta Veterans Affairs Medical Center's Outpatient Parenteral Antimicrobial Program

By

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Bachelor of Science
Syracuse University
2018

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An abstract of
A thesis submitted to the Faculty of the
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Abstract

Assessing Safety and Outcomes of the Atlanta Veterans Affairs Medical Center's Outpatient Parenteral Antimicrobial Program
By William Rich

Background

The Atlanta VA medical center (AVAMC) utilizes outpatient parenteral antimicrobial therapy (OPAT) to treat a wide range of infections which do not require hospitalization. OPAT has similar outcomes to inpatient care while reducing costs, increasing patient satisfaction, and increasing patient autonomy.

Objective

In this study, the authors seek to understand the population of patients in the AVAMC OPAT program and explore risk factors for hospital readmission, adverse drug events (ADEs), and failure of therapy.

Methods

The medical charts of OPAT patients receiving care between January 1, 2019 and June 30, 2022 were reviewed. We included patients who completed their OPAT course at home and who were over the age of 18. We collected information about demographics, incident hospitalization, hospitalization antimicrobials, OPAT indication, infectious agent, OPAT antimicrobials, ADEs, patient follow-up, and resolution of infection. We also conducted univariate and multivariate logistic regression analyses of patients with a musculoskeletal condition (MSK) with no change in their OPAT course.

Results

Full Cohort

Among our full cohort, diabetes was associated with an increased risk of failure with a risk ratio (RR) of 1.68 (95% CI 1.01-2.77). Patients who received follow-up had a RR of 0.39 (95% CI: 0.21-0.73) for rehospitalization compared to patients who did not receive follow-up.

MSK Cohort

For patients in the MSK group with diabetes, risk of failure was 1.50 times higher than those without diabetes (95% CI: 0.67-3.34), however the association was not statistically significant. The RR for rehospitalization was 0.23 (95% CI: 0.06-0.82) for patients who received follow-up compared to patients who did not receive follow-up.

Conclusion

More research needs to be conducted on the use of OPAT in patients with diabetes. We also want to emphasize the importance of prompt patient follow-up to reduce the risk of rehospitalization among OPAT patients. We plan on collecting more data and conducting further analyses on the full cohort and on subsets of patients.

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Table of Contents

Background

Outpatient Parenteral Antimicrobial Therapy (OPAT) as defined by the Infectious Disease Society of America (IDSA), is "the administration of parenteral antimicrobial therapy in at least 2 doses on different days without intervening hospitalization."[1] It has repeatedly been demonstrated to be safe and effective in treating a wide range of conditions including deep seated bone and joint infections, endocarditis, and multidrug resistant organisms.[1–5] OPAT is used when oral antimicrobial therapies are not an option for treatment but hospitalization is not necessary and outpatient care is sufficient. OPAT is a common therapy used to treat complex infections which do not require hospitalization. It has also been shown to increase patient satisfaction, reduce length of hospitalization and lower costs for both patients and healthcare facilities.[5,6]

Inpatient care is incredibly burdensome for families. Acute care hospitalization carries heavy costs and risks for patients and their families especially as length of stay is extended for services not requiring acute level care.[7,8] Expenses and risks include economic cost, patient isolation, loss of patient autonomy, and increased risk for hospital-acquired infections (HAI) due to more time in facilities[7]. Finding ways to reduce the cost and time commitment is of the utmost importance to improving livelihoods of the patients and their caregivers. OPAT allows some level of autonomy and ability to continue working while undergoing care for complicated infections which do not require hospitalization. A meta-analysis of pediatric OPAT patients found OPAT was 30-75% cheaper than inpatient care, even if was longer and home nursing assistance was utilized.[9] The same study found listed reasons for preference of OPAT over inpatient treatment included keeping up with school and work, greater privacy and comfort, improved sleep and appetite, and higher-quality familial relationships.[9] As the use of OPAT

expands, especially in the post-COVID-19 era, there is greater need to increase insurance coverage for OPAT as well as increase utilization of outpatient services to free beds in healthcare facilities.[10]

OPAT benefits emergency facilities and acute care hospitals greatly through a reduction in inpatient utilization rates.[3,5,6,9] This leads to more availability when necessary, allowing surge capacity to increase. A Belgian study of OPAT found that among 152 incidences of OPAT among 130 patients, over 3000 inpatient days were avoided through early discharge.[3] A ten year study at a single teaching hospital in the UK found nearly 50,000 bed days were saved, with success in 88% of all patients.[5] These savings of in-hospital days free up beds necessary for other individuals and enables limited care resources to be allocated to those with the highest need.

OPAT is a complex process which necessitates careful selection of patients, therapeutics, and care location for successful implementation. IDSA released updated guidance on OPAT in 2018 to assist with patient screening and selection.[1] In this guidance, the authors outline 17 patient considerations with how strong the recommendation is and the quality of the supporting evidence. Recommendations include considerations to caregiver support, injection drug usage, patients with specific pre-existing conditions such as chronic kidney disease, pediatric OPAT patients, and physician visits for monitoring.

With each location, there are different benefits and risks, with costs, freedoms, and levels of autonomy and professional assistance varying between each.[5] OPAT care can be conducted in a variety of settings including outpatient healthcare facilities such as hemodialysis (HD) or infusion centers, skilled nursing facilities (SNF), and home environments. SNF has the highest level of care associated with OPAT. HD and infusion clinics offer assistance with each infusion and are able to assist with questions or concerns at the time of infusion as well as draw labs for

the OPAT care administrator. Home-based is the most difficult to manage. Some individuals will infuse their own or utilize friends or family to assist. Others will hire home nursing staff to assist with care either at each infusion or on a rotating schedule during their care.

Insurance and location of administration can have effects on different therapies available.[1,10,11] This presents an additional challenge in determining candidates for OPAT and ensuring their effective treatment. For example, Medicare Part A only covers home nursing if the insured patient is homebound, Medicare Part B covers less than 10% of OPAT antimicrobials, and Medicare Part D does not cover the supplies or nursing services necessary for OPAT.[10,11] As such, many are discharged to SNFs to undergo covered care which is more strenuous on patients than home care and increases workloads in facilities with minimal resources[10]. For home-based OPAT, some individuals will hire nursing staff to administer therapies while others will self-administer or utilize assistance from friends and family. There is difficulty in managing care in an outpatient setting, and frequently there are needs can only be met at inpatient settings. As such, selection of location is vital to consider too when selecting OPAT candidates, with criteria including safety of home, recreational intravenous drug usage, need of wound care, and home-based assistance.[10]

As explored above, the process of selecting patients can be complex. One reason for this is the extensive list of challenges to successfully completing an OPAT course. One study in Virginia found common challenges in their program were a lack of home support leading to greater rehospitalization rates, significant rates of ADEs, and lack of patient follow-up. This study found that of their population that was re-hospitalized, 85.7% were initially discharged to home for care.[12] This highlights the need to appropriately screen candidates and ensure they have sufficient support before their admission to an OPAT program.

While uncommon, patients participating in OPAT may experience unexpected events including adverse drug events (ADE) such as supratherapeutic antibiotic levels or nausea, and venous access events (VAE) such as accidental or intentional dislodgement of the venous catheter. ADEs and VAEs present a substantial risk among patients and significant cost to healthcare systems, with one study finding that approximately 18% of their OPAT program participants recorded an ADE.[13] They can fall into multiple categories including side effects, renal disfunction, and drug-drug interactions (DDI). One study examining OPAT in a Veterans Affairs (VA) hospital in Buffalo, NY found that among patients with an ADE during their OPAT course, odds of failure of therapy was 10.1 times higher compared to those without an ADE during their therapy.[14] Another study from Johns Hopkins OPAT program found the first two weeks in an OPAT course had the highest rates of ADEs. The authors posited this was due to the challenges of transitioning care from inpatient to outpatient.[13]

While there is a plethora of information examining risk factors for failure of therapy or unsafe outcomes of OPAT given specific conditions or therapies, there is a dearth of information exploring general risk factors for failure of therapy or unsafe outcomes. When the IDSA updated their OPAT guidance in 2018, many of their recommendations had low-quality evidence, even if they were strong recommendations.[1] This highlights the need for further high-quality evidence on risks for failure of OPAT therapy and factors that may lead to adverse drug events or other poor safety outcomes.

In this study, the authors seek to understand and describe the Atlanta VA Medical Center (AVAMC) program participants more wholistically. We hope to characterize demographic and health status as well as infection characteristics. To understand the course of OPAT, we will also characterize the infection, infectious agent, and antibiotics used. We wanted to understand risks

for failure of therapy and ADEs in our cohort. We also wanted to understand the types of infections and organisms we see, treatments used, length of OPAT, and rates and types of ADEs and VAEs. We ultimately want to compare groups to understand risk factors for failure of therapy, with the ability to control for factors such as location, microbiology, condition, pre-existing conditions, and more. We hope to understand why patients who fail their therapy are failing and how to improve both patient selection and patient outcomes.

Methods

To appropriately assess outcomes with a common exposure, we used a retrospective cohort study design whose protocol was approved by the Emory University Institutional Board Review and the AVAMC Research and Development Committee. Patients were included in the data collection if they were older than 18 years, their OPAT course was conducted between January 1, 2019 and June 30, 2022, and their course of OPAT was completed at home, outside of the hospital setting (i.e. not in the emergency room). To be inclusive and account for patients who may have received long acting lipoglycopeptides, all participants had a course of OPAT with at least one dose of parenteral antibiotics received at home. Data was collected from the VAMC's Computerized Patient Record System (CPRS) and entered into a researcher-made database on the Research Electronic Data Capture (REDCap) software hosted on-site at the AVAMC. REDCap is designed by Vanderbilt University and licensed to the VA. It is a secure, web-based platform designed for assisting with data collection, storage, and exportation.[15] For our analysis, we used both Microsoft® Excel® version Microsoft365 and SAS® version 9.4 to conduct descriptive epidemiology, univariate and multivariate analyses.

Patient-specific information collected includes demographic information, mental health diagnoses, social factors, and comorbidities. Demographic information includes age, race, and sex. Mental health diagnoses include depression, anxiety, post-traumatic stress disorder (PTSD),

schizophrenia, and other. Social factors include alcohol, tobacco, drug, and IV drug use as well as housing stability and home support. Comorbidities were collected and organized in accordance with the Charlson Comorbidity Index (CCI). To establish baseline health status for each patient, the researchers chose to use an age-adjusted version of the CCI. CCI uses 19 weighted conditions to predict one-year mortality.[16] Different conditions are assigned different scores ranging from one to six, with higher scores leading to higher risk of one-year mortality. Conditions and respective scores in CCI calculations are[17]:

Condition	Score
Cerebrovascular Disease	1
Chronic Pulmonary Disease	1
Congestive Heart Failure	1
Connective Tissue Disease	1
Dementia	1
Diabetes	1
Mild Liver Disease	1
Myocardial Infarction	1
Peripheral Vascular Disease	1
Ulcer Disease	1
Any Tumor without Metastasis	2
Diabetes with End Organ Damage	2
Hemiplegia	2
Leukemia	2
Lymphoma	2
Moderate or Severe Renal Disease	2
Moderate or Severe Liver Disease	3
AIDS	6
Metastatic Solid Tumor	6

The authors of the original 1987 publication also found age to be a predictive factor when testing their original model[17], and subsequent models have been created to account for age.[16,18] CCI has repeatedly been used in a wide variety of contexts to understand its limitations and it has repeatedly been found to be an excellent predictor of risk and mortality.[16] In our study, we

adjusted age through the following formula: <50 = CCI+0; 50-59 = CCI+1; 60-69 = CCI+2; 70-79 = CCI+3; 80-89 = CCI+4; 90-99 = CCI+5; 100+ = CCI+6.

The researchers utilized the conditions for calculating CCI as a set list of pre-existing conditions as well as social factors including housing stability, mental health diagnoses, and tobacco, alcohol, and drug use. This allowed a baseline health value for each individual to be established and a way to compare individuals across different conditions, therapies, and microbiology to observe overall risk factors of failure of OPAT and ADEs.

We categorized diagnosis condition and microbiology into over 15 variables each as well. Diagnoses collected were bone infection, joint infection, prosthetic infection, bacteremia, complicated urinary tract infections (UTI), endocarditis, diabetic foot infection including foot osteomyelitis, cellulitis, vascular graft, pneumonia, neurosyphilis, septic arthritis, vertebral discitis/vertebral osteomyelitis, intraabdominal abscess, psoas abscess, and other. Microbiology included MRSA, MSSA, *S. epidermis, S. lugdunensis*, other coagulase negative staphylococcus, group B *Streptococcus*, other *Streptococci spp.*, *Enterococcus*, other gram-positive organisms, *E. Coli, Proteus, Serratia, P. aeuriginosa*, other gram-negative organism, *Bacteroides*, anaerobic organisms, *Klebsiella spp.*, *Candida spp.*, other, and unknown.

In this study, we are focusing on musculoskeletal (MSK) infections. Among our cohort, we are considering MSK conditions to include: bone infection; joint infection; prosthetic infection; diabetic foot infection including diabetic foot osteomyelitis; septic arthritis; vertebral discitis including vertebral osteomyelitis; and psoas abscess. We chose to focus on this subset of infections for our analysis due to the prevalence of MSK infection in our cohort (64%) and to controlled for condition-based confounding factors such as length of OPAT. We compared the group of MSK patients by whether their first course of OPAT was altered **(**Tables 7-11). We did

this in an effort to understand if there may be factors that affect the course of OPAT and to characterize them.

For pharmaceutical therapies, we collected both intravenous and oral antibiotics during hospitalization and up to five rounds of OPAT due to changes in therapy. Dates of hospitalization admission and discharge and duration of OPAT course were collected. We have over 20 drugs for intravenous usage (hospital and OPAT) and 10 for oral (hospital and discharge prescription). Intravenous antibiotics include 5 beta-lactams (penicillin, ampicillin, ampicillin/sulbactam, nafcillin, and piperacillin-tazobactam), 7 cephalosporins (cefazolin, ceftriaxone, cefepime, ceftazidime, ceftaroline, ceftazidime, ceftazidime-avibactam, and ceftolozane-tazobactam), 2 carbapenems (ertapenem and meropenem), 2 aminoglycosides (amikacin and gentamicin) and in their own categories, vancomycin, dalbavancin, daptomycin, metronidazole, and an "other" category. Oral drugs collected included rifampin, levofloxacin, ciprofloxacin, moxifloxacin, doxycycline, minocycline, linezolid, cefadroxil, cephalexin, cefpodoxime, metronidazole, and other.

Data on adverse events was broken into ADEs or VAEs. We collected data on type and timing of event. The ADEs include supratherapeutic drug level, acute kidney injury, acute hepatocellular injury, hematologic abnormality, elevated creatine kinase, allergic reaction, drug interaction, patient intolerance, diarrhea, nausea/vomiting, and *C. difficile*. The VAEs include peripherally inserted central catheter (PICC) malfunction, need for antithrombotic agent, dislodgement (unintentional or intentional), cellulitis, PICC dressing allergic reaction, bloodstream infection, inability to draw labs (without need for antithrombotic agent), and other.

As our study period straddles both before and after the COVID-19 pandemic outbreak, we collected information on follow-up within 30 days of starting OPAT and, if follow-up was completed, whether it was completed in-person or remotely.

For this study, success was defined as clinical resolution through OPAT within 6 months of the conclusion of the course of OPAT. We examined medical records for 6 months after the conclusion of an individual's OPAT course to find evidence of clinical resolution. We classified success as a binary, not by have differing levels of success based on changing of course as some studies have in the past.[19]

Results

Entire Cohort

Our OPAT cohort was primarily male, representing 92% of the population. Our population was 87% non-Hispanic. There were 66 (44%) patients identifying as white and 66 (44%) of patients self-identifying as black. Our population had a median age of 66 years, with a total range of 26 to 88 years. The most prevalent pre-existing condition present was diabetes (54%) with many other conditions being present in smaller cohorts (Table 1).

The most common indications among the entire OPAT group included bone infection, diabetic foot infections, and bacteremia. Bone infections were seen in 44 (30%) patients, consisting of 22% of diagnoses. Diabetic foot infections were seen in 36 (24%) patients, consisting of 18% of diagnoses. Bacteremia was seen in 30 (20%) patients, consisting of 15% of diagnoses. 19 patients had an unidentified pathogen. Among patients with a pathogen recovered, 95 (64%) were monomicrobial while 41 (28%) patients were polymicrobial. The most common organisms were Methicillin-susceptible *S. aureus* (MSSA), *E. Coli*, and *Enterococcus*, infecting 30 (20%), 16 (11%), and 15 (10%) patients respectively (Table 3).

The OPAT course length ranged from one to 74 days, with a median of 34 days and a mean of 31.8 days. 123 (83%) patients were initially prescribed one antimicrobial while 26 (17%) were on two antimicrobials. 43 (29%) patients needed an alteration to their initial OPAT course. (Table 4). Within our entire patient population, 96 (64) patients received follow-up, of which 53 were conducted remotely and 41 in-person. Two patients were missing follow-up method. Twenty-nine patients (19.6%) were re-hospitalized. Indicators for rehospitalization were disease progression (11 patients), inability to self-care/manage infection (3 patients), ADE (1 patient), and VAE (1 patient) (Table 5).

MSK Cohort

Among our MSK cohort, 15 patients had no identified pathogen. Of those with pathogens identified, 43 (67%) were monomicrobial while 19 (30%) were monomicrobial. *S. aureus* was the most common organism with 33 specimens (34%). MSSA accounted for 24 and Methicillin-resistant *S. aureus* (MRSA) accounted for 9 of all *S. aureus* cases. *Enterococcus* and other coagulase-negative *Staphylococcus* were the only other organisms seen in more than 10 patients, being found in 14 and 11 patients respectively.

Among the MSK group, the three most common OPAT indications were bone infections (N=43), diabetic foot infections (N=36), and prosthetic infections (N=11). The MSK group's OPAT course lasted for a median and mean of 38 days, with a range of 1 to 74 days. Our MSK group was primarily treated with cephalosporins (N=45, 64%) or daptomycin (N=23, 24%) (Table 10). 32 (33%) MKS patients had a change in their initially prescribed course.

Entire Cohort Analysis

Univariate and multivariate log-binomial analyses were conducted to examine factors associated with failure of the OPAT course among the entire cohort (Table 6). Among the entire

cohort, diabetes and an alteration in the initial OPAT course were both associated with failure of therapy. Diabetes had a risk ratio (RR) of failure of 1.68 (1.01-2.77) and course alteration had an RR of 1.81 (1.15-2.86). Only two factors were found to be significant; the use of vancomycin during the incident hospitalization was found to be protective with a risk ratio (RR) of 0.48, (95% CI: 0.24-0.97, p-value: 0.04) and infection with a coagulase-negative *Staphylococcus* microorganism not in our list of pre-selected coagulate-negative *Staphylococcus* organisms was found to increase risk, with an RR of 2.54 (95% CI: 1.36-4.76, p-value: 0.004). In a univariate analysis comparing rehospitalization with patient follow-up, those with follow-up had an RR of readmission of 0.39 (0.21-0.73, p-value 0.0033) compared to those without follow-up.

MSK Cohort Analysis

Univariate and multivariate log-binomial analyses were also conducted to examine factors associated with failure of the OPAT course among MSK patients with no alteration in their initial OPAT course (Table 12). Among the MSK group without alteration in course, diabetes had a similar RR of 1.50 (95% CI: 0.67-3.34), however the result was not statistically significant. Similar to the whole cohort, rehospitalization was significantly lower among those who received follow-up compared to those who did not receive follow-up, with a RR of 0.23 (95% CI: 0.06-0.82).

Discussion

Our OPAT cohort is varied with over 15 indications and over 15 infectious agents represented in our 149 patients. Our smaller MSK cohort was also well represented with 7 indications and over 15 infectious agents. This allowed us to conduct a wide array of tests, however it did affect our ability to conduct thorough assessments with multivariate analyses. Our univariate analyses found interesting associations failure of therapy and diabetes, and

rehospitalization and patient follow-up. We also want to discuss the low rates of debridement testing and what impacts that may have.

Diabetes and severe diabetes have negatively impacted rates of successful resolution of infection in our study population. While the authors of this study do not know why this is, we plan on doing further research with our data to understand factors which may be contributing to this association. A study conducted in the UK found diabetes was associated with both OPAT failure and longer courses of OPAT in their analyses.[20] Once reducing the cohort to solely MSK infections with no course alteration, the effect of diabetes, while still a similar RR, was no longer statistically significant. This could in part be due to a smaller cohort (N=64 vs N=149). As we collect further data, we plan to further explore the relationship between diabetes and failure of OPAT to resolve infection.

There is a growing body of evidence showing that patient follow-up is associated with positive outcomes. This includes both follow-up with patients soon after starting OPAT to ensure continuity of care and monitoring of any effects routine blood lab work may not test for. A study conducted at 2 Emory hospitals found those with any follow-up and odds of 30 day readmission was 0.16 times those who did not receive follow-up.[21] Our rates of rehospitalization were similar to this study. We found profound effects in both our total cohort and our MSK cohort in the effect of patient follow-up on reducing rehospitalization. This finding emphasizes the need to follow-up with patients throughout their OPAT course to ensure patient safety is upheld.

A study in western Australia examined fully remote administration of OPAT. Their review of 88 OPAT instances among 83 patients found comparable rates of success compared other studies and their own data.[22] This suggests new avenues of care for individuals with less interaction with healthcare systems and greater opportunities of care delivery, especially for

patients with mobility limitations and patients with comorbidities who may not want to visit an acute care hospital if not necessary.

Another important finding in our review is that just 35.7% of those who received surgical debridement are known to have clear margins. In the MSK group, this dropped to 29% of patients. This underscores both the need for testing of margins and ensuring the margins are clear, as recommendations are for clear surgical margins to treat with a shorter course of antibiotics.[23] This is especially important given the impact it had on those with diabetes and severe diabetes in the full cohort. Fully understanding the impact of debridement and success or failure of OPAT will need further research.

Conclusion

There is a dearth of information regarding overall risk factors for OPAT. Our research implies that alteration and length of OPAT may be associated with increased risk of failure, however we did not control for many associated factors. It additionally shows diabetics and those with severe diabetes may be at heightened risk for therapy failure. More research is needed on both areas to examine further risk factors and determine when OPAT may not be appropriate. We also intend to further explore patient follow-up and its impact with success of therapy, especially with differences between in-person and remote follow-up outcomes in the age of COVID-19. Our dataset runs from January 1, 2019 to June 20, 2022. This allows us to examine follow-up method and rates of failure of therapy, ADEs, and rehospitalization before and after COVID-19 lockdowns to observe a change in rates of follow-up and if there is any impact on success.

Our biggest limitation is our small dataset. Our entire cohort consists of 149 patients, however we collected such a large volume of data and the patient population is so varied, it can be difficult to do complete analyses while controlling for appropriate factors such as OPAT

indication. We attempted to solve this by using smaller data subsets such as the MSK subset to alleviate some of the confounding by indication and length of OPAT which are closely tied, however result precision was affected. This has also been problematic as prior literature has shown persons assigned female at birth have higher rates of OPAT failure, but our data did not have enough female representation to conduct adequate assessments.[20]

Additionally, CCI as a means of standardization may be a limitation. Many studies have explored adapting CCI for certain conditions or situations, including stroke and age.[16,18,24,25] CCI, created in 1987, may be outdated with inaccurate risk scores. In 1987 when the list was released, there were no antiretroviral therapies for AIDS.[26] AIDS is no longer the death sentence it once was, but the score to predict one year mortality has not been updated. It also fails to consider variability within conditions, such as controlled and uncontrolled diabetes, or managed and unmanaged AIDS. CCI's lack of updating means the weighting of the conditions may no longer be as accurate as they once were, which is a limitation when attempting to control for CCI as a whole.

This research is meant to guide future AVAMC OPAT treatment while further data collection is completed and analyzed. Future research will explore more information related to the findings in this paper. We will also explore the impact of OPAT administration location as we collect further information from patients receiving OPAT at SNFs and hemodialysis clinics.

Tables

Table 1. Demographics of the 149 OPAT patients in Atlanta, GA

	N (%) unless otherwise stated
Age (years)	
Median	66
Min, Max	26, 88
Sex	
Male	137 (92)
Female	7 (5)
Ethnicity	
Non-Hispanic or Latino	130 (87)
Hispanic or Latino	2 (1)
Missing	17 (11)
Race	
White/Caucasian	66 (44)
Black/African American	66 (44)
Other/Missing	17 (11)
Mental Health Diagnoses	
Depression	47 (32)
PTSD	19 (13)
Anxiety	15 (10)
Bipolar Disorder	5 (3)
Schizophrenia	1 (1)
None	70 (47)
Social Factors	
Tobacco Use	31 (21)
Alcohol Use Disorder	14 (9)
Illicit Drug Use	10 (7)
IV Drug Use	0 (0)
Homeless/Housing Insecurity	2 (1)
Age-Adjusted Charlson Comorbidity Index Factors	
Diabetes	80 (54)
Diabetes with End Organ Damage	52 (35)
Chronic Lung Disease	26 (17)
Peripheral Vascular Disease	26 (17)
Moderate to Severe Kidney Disease	22 (15)
Cerebrovascular Disease	17 (11)
Congestive Heart Failure	17 (11)
Hemiplegia	17 (11)
Chronic Liver Disease	16 (11)
Dementia	13 (9)

Malignant Tumor	13 (9)
AIDS	6 (4)
Myocardial Infarction	4 (3)
Metastatic Cancer	3 (2)
Lymphoma	2 (1)
Moderate to Severe Liver Disease	2 (1)
Peptic Ulcer Disease	2 (1)
Connective Tissue Disorder	1 (1)
Leukemia	0 (0)
Age Categories	
Under 50	15 (10)
50-59	19 (13)
60-69	58 (39)
70-79	48 (32)
80-89	9 (6)
Distribution of CCI Scores	
Median	5
Min, Max	0, 19

Due to rounding, percentages may not add to 100.0
Due to missing data, row totals may not add to N

Table 2. Diagnostic and microbiologic indications for OPAT among 149 patients

	149 Patients	197 Diagnoses
Diagnoses	N (%)	N (%)
Bone Infection	44 (30)	44 (22)
Diabetic Foot Infection Including Foot Osteomyelitis	36 (24)	36 (18)
Bacteremia	30 (20)	30 (15)
Cellulitis	14 (9)	14 (7)
Other	14 (9)	14 (7)
Complicated UTI	12 (8)	12 (6)
Prosthetic Infection	11 (7)	11 (6)
Neurosyphilis	9 (6)	9 (5)
Vertebral Discitis/Vertebral Osteomyelitis	7 (5)	7 (4)
Endocarditis	6 (4)	6 (3)
Intraabdominal Abscess	4 (3)	4 (2)
Pneumonia	3 (2)	3 (2)
Psoas Abscess	3 (2)	3 (2)
Septic Arthritis	2 (1)	2 (1)
Joint Infection (Not Prosthetic)	1 (1)	1 (1)
UTI	1 (1)	1 (1)
Vascular Graft	0 (0)	0 (0)
	149 Patients	185 Organisms
Microbiology	N (%)	N (%)
MSSA	30 (20)	30 (16)
E. Coli	16 (11)	16 (9)
Enterococcus	15 (10)	15 (8)
Other Gram-Negative Organism	14 (9)	14 (8)
MRSA	12 (8)	12 (7)
Other Coagulase-Negative *Staphylococcus*	12 (8)	12 (7)
Other *Streptococci spp.*	12 (8)	12 (7)
Pseudomonas aeruginosa	12 (8)	12 (7)
Proteus	10 (6)	10 (5)
Group B *Streptococcus*	7 (5)	7 (4)
S. Epidermidis	6 (4)	6 (3)
Other Gram-Positive Organism	4 (3)	4 (2)
Klebsiella spp.	4 (3)	4 (2)
S. Lugdunensis	3 (2)	3 (2)
Serratia	2 (1)	2 (1)
Anaerobic Organisms	2 (1)	2 (1)
Other	5 (3)	5 (3)
Unknown	19 (13)	19 (10)
Number of Infective Organisms		N(% of 149)

Monomicrobial	95 (64)
Polymicrobial	41 (28)
Missing	13 (9)
Min, Max	0, 4

Due to rounding, percentages may not add to 100.0
Due to missing data, row totals may not add to N

Table 3. Characterization of 149 patients' incident hospitalization before entering the AVAMC's OPAT program

Length of Stay (Days)		
Median		8
Min, Max		0, 50
	149 Patients	296 Inpatient IV Drugs
Incident Hospitalization IV Drugs	N (%)	N (%)
Cephalosporins	104 (70)	104 (35)
Vancomycin	79 (53)	79 (27)
Beta-Lactams	50 (34)	50 (17)
Carbapenems	31 (21)	31 (11)
Daptomycin	20 (13)	20 (7)
Metronidazole	4 (3)	4 (1)
Dalbavancin	1 (1)	1 (0)
Aminoglycosides	1 (1)	1 (0)
Fluoroquinolone	1 (1)	1 (0)
Rifampin	0 (0)	0 (0)
Other	5 (3)	5 (2)
Number of Drugs		N (%)
Outpatient OPAT start --		18 (12)
Mono-antimicrobial		38 (26)
Poly-antimicrobial		93 (62)
Min, Max		0, 6
Surgical Debridement (N=56)		N (%)
Surgical Margins Clear		20 (36)
Surgical Margins Not Clear		24 (43)
Unknown Success		12 (21)

Due to rounding, percentages may not add to 100.0
Due to missing data, row totals may not add to N

Table 4. OPAT Course Among 149 Patients at AVAMC

	149 Patients	175 Drugs Prescribed
Initially Prescribed Drug	N (%)	N (%)
Cephalosporins	66 (44)	66 (38)
Beta-Lactams	28 (19)	28 (16)
Daptomycin	27 (18)	27 (15)
Carbapenems	26 (17)	26 (15)
Vancomycin	22 (15)	22 (13)
Dalbacvancin	4 (3)	4 (2)
Aminoglycocides	1 (1)	1 (1)
Metronidazole	1 (1)	1 (1)
Other	0 (0)	0 (0)
Number of Drugs		N (%)
Mono-antimicrobial		123 (83)
Poly-antimicrobial		26 (18)
Min, Max		1, 2
Length of Overall Course		Days
Median		34
Min, Max		1, 74
Initial Drug/Dosage Change		N (%)
Change in OPAT course		43 (29)

Due to rounding, percentages may not add to 100.0
Due to missing data, row totals may not add to N

Table 5. OPAT Course Outcomes Among 149 Patients at AVAMC

Resolution	N (%)
Evidence of Resolution through OPAT at 6 months	101 (68)
Adverse Drug Events	N (%)
Acute Kidney Injury	9 (6)
Patient Intolerance	5 (3)
Hematologic Abnormality	4 (3)
Supratherapeutic Drug Level	3 (2)
Allergic Reaction	3 (2)
Acute Hepatocellular Injury	1 (1)
Elevated Creatine Kinase	0 (0)
Drug Interaction	0 (0)
Diarrhea	0 (0)
Nausea/Vomiting	0 (0)
Total	25 (100)
Venous Access Events	N (%)
Dislodgement (Accidental or intentional)	7 (5)
PICC Malfunction	6 (4)
Blockage	2 (1)
Inability to Draw Labs	2 (1)
Cellulitis	0 (0)
PICC Dressing Allergic Reaction	0 (0)
Bloodstream Infection	0 (0)
Other	3 (2)
Total	20 (100)
Follow-up within 30 days of beginning OPAT course (N=96)	N (%)
Remote	53 (55)
In Person	41 (43)
Rehospitalization	N (%)
Re-hospitalized	29 (20)
Disease Progression	11 (7)
Inability to self-care/manage infection	3 (2)
ADE	1 (1)
VAE	1 (1)
C. difficile	0 (0)

Due to rounding, percentages may not add to 100.0

Due to missing data, row totals may not add to N

Table 6. Univariate association between select patient characteristics and failure to resolve infection through OPAT among 149 patients

Patient Characteristics	Risk Ratio (95% CI)	P-Value
Diabetes*	1.68 (1.01-2.77)	0.05
Severe Diabetes	1.58 (1.00-2.49)	0.05
Illicit Drug Use	1.33 (0.89-1.99)	0.16
Number of Mental Health Diagnoses	0.72 (0.39-1.31)	0.28
Chronic Lung Disease	0.68 (0.32-1.42)	0.30
Tobacco Use	0.74 (0.39-1.40)	0.35
Hemiplegia	1.32 (0.71-2.47)	0.37
Chronic Liver Disease	0.77 (0.32-1.86)	0.56
Alcohol Use Disorder	1.08 (0.72-1.63)	0.71
Age	1.00 (0.98-1.02)	0.74
Cerebrovascular Disease	1.10 (0.55-2.20)	0.79
Congestive Heart Failure	1.10 (0.55-2.20)	0.79
Length of Hospitalization	1.00 (0.97-1.04)	0.97
Hospital IV Drugs		
Carbapenems	1.57 (0.97-2.53)	0.07
Beta-lactams	0.78 (0.47-1.28)	0.33
Vancomycin	0.82 (0.51-1.30)	0.39
Daptomycin	1.29 (0.71-2.34)	0.40
Cephalosporins	0.98 (0.70-1.37)	0.90
1st OPAT Course		
Daptomycin	1.34 (0.79-2.28)	0.27
Vancomycin	1.15 (0.63-2.12)	0.64
Beta-lactams	0.86 (0.46-1.64)	0.65
Carbapenems	1.09 (0.61-1.97)	0.77
Cephalosporins	1.06 (0.67-1.70)	0.79
Patient Follow-up Status	0.91 (0.59-1.42)	0.70
First OPAT Course Alteration*	1.81 (1.15-2.86)	0.01

* Denotes a statistically significant finding
Due to rounding, percentages may not add to 100.0
Due to missing data, row totals may not add to N

Table 7. Characterization of Patients with a Musculoskeletal Condition Compared by Status of Initial OPAT Course Alteration

	64 Patients with no OPAT Alteration N (%)	32 Patients with OPAT Alteration N (%)
Race		
White/Caucasian	26 (41)	15 (47)
Black/African American	31 (48)	12 (38)
Native American/Alaska Native	2 (3)	0 (0)
Missing	5 (9)	5 (16)
Ethnicity		
Non-Hispanic	55 (86)	26 (81)
Hispanic	0 (0)	1 (3)
Missing	9 (14)	5 (16)
Age		
Median	66.5	63
Min, Max	37, 87	37, 88
Age Category		
Under 50	6 (9)	2 (6)
50-59	8 (13)	6 (19)
60-69	25 (39)	17 (53)
70-79	20 (31)	5 (16)
80-89	5 (8)	2 (6)
Social Factors		
Depression	22 (34)	7 (22)
Tobacco Product User	12 (19)	9 (28)
PTSD	10 (16)	3 (9)
Alcohol Use Disorder	8 (13)	2 (6)
Illicit Drug User	6 (9)	1 (3)
Bipolar Disorder	3 (5)	1 (3)
Anxiety	2 (3)	3 (9)
Schizophrenia	1 (2)	0 (0)
No History of Mental Health Diagnoses	31 (48)	16 (50)
CCI Factors		
Diabetes	40 (63)	19 (59)
Diabetes with End Organ Damage	29 (45)	15 (47)
Chronic Lung Disease	13 (20)	1 (3)
Peripheral Vascular Disease	12 (19)	11 (34)
Moderate to Severe Kidney Disease	12 (19)	4 (13)
Congestive Heart Failure	7 (11)	3 (9)
Mild Liver Disease	7 (11)	3 (9)
Hemiplegia or Paraplegia	6 (9)	4 (13)
Cerebrovascular Disease	4 (6)	5 (16)
Malignant Tumor	4 (6)	2 (6)
AIDS	4 (6)	0 (0)
Dementia	2 (3)	2 (6)

Myocardial Infarction	2 (3)	1 (3)
Peptic Ulcer Disease	1 (2)	1 (3)
Moderate to Severe Liver Disease	0 (0)	1 (3)
CCI Distribution		
Median	6	5
Min, Max	0, 17	0, 12

Due to rounding, percentages may not add to 100.0
Due to missing data, row totals may not add to N

Table 8. Indication and Microorganisms Identified among 97 MSK patients

	64 Patients with no OPAT Alteration	32 Patients with OPAT Alteration
MSK OPAT Indication	N (%)	N (%)
Prosthetic Infection	8 (13)	3 (9)
Vertebral Discitis/Osteomyelitis	3 (5)	4 (13)
Psoas Abscess	2 (3)	1 (3)
Septic Arthritis	1 (2)	1 (3)
Joint Infection	0 (0)	1 (3)
Bone Infection	30 (47)	13 (41)
Diabetic Foot Infection/Osteomyelitis	24 (38)	12 (38)
Microbiological Organism Identified		
MSSA	16 (25)	8 (25)
Enterococcus	8 (13)	6 (19)
Other Coagulase Negative *Staphylococcus*	7 (11)	4 (13)
Proteus	7 (11)	2 (6)
MRSA	6 (9)	3 (9)
E. coli	5 (8)	1 (3)
Other Gram-Negative Organism	5 (8)	2 (6)
Group B *Streptococcus*	4 (6)	2 (6)
Other *Streptococci spp.*	4 (6)	5 (16)
S. epidermidis	3 (5)	3 (9)
Other Gram-Positive Organism	3 (5)	0 (0)
Pseudomonas aeruginosa	3 (5)	2 (6)
S. lugdunensis	2 (3)	1 (3)
Klebsiella spp.	1 (2)	1 (3)
Serratia	0 (0)	1 (3)
Anaerobic Organisms	0 (0)	1 (3)
Other Organism	1 (2)	0 (0)
Unknown Organism	12 (19)	3 (9)
Number of Organisms Identified		
Monomicrobial	43 (67)	17 (53)
Polymicrobial	19 (30)	32 (41)

Due to rounding, percentages may not add to 100.0

Due to missing data, row totals may not add to N

Table 9. Characterization of inpatient hospitalization among 97 MSK patients

	64 Patients with no OPAT Alteration N (%)	32 Patients with OPAT Alteration N (%)
Hospital IV Antimicrobials Administered		
Hospital IV Vancomycin	39 (61)	22 (69)
Hospital IV Cephalosporin	29 (45)	19 (59)
Hospital IV Beta-Lactam	24 (38)	10 (31)
Hospital IV Daptomycin	7 (11)	8 (25)
Hospital IV Carbapenem	7 (11)	7 (22)
Other Hospital IV Drug	2 (3)	0 (0)
Hospital IV Dalbavancin	1 (2)	0 (0)
Hospital IV Metronidazole	1 (2)	1 (3)
Hospital IV Fluoroquinolone	1 (2)	0 (0)
Number of Drugs		
Monoantimicrobial	11 (17)	6 (19)
Polyantimicrobial	41 (64)	26 (81)
Min, Max	0, 5	1, 5

Due to rounding, percentages may not add to 100.0
Due to missing data, row totals may not add to N

Table 10. Characterization of OPAT course of 97 MSK patients

	64 Patients with no OPAT Alteration	32 Patients with OPAT Alteration
OPAT Antimicrobial Administered	N (%)	N (%)
1st Course OPAT Cephalosporin	30 (47)	15 (47)
1st Course OPAT Daptomycin	13 (20)	10 (31)
1st Course OPAT Vancomycin	9 (14)	7 (22)
1st Course OPAT Beta-Lactam	9 (14)	6 (19)
1st Course OPAT Carbapenem	7 (11)	3 (9)
1st Course OPAT Dalbavancin	4 (6)	0 (0)
1st Course OPAT Metronidazole	1 (2)	0 (0)
1st Course OPAT Aminoglycoside	1 (2)	0 (0)
Number of Drugs		
Monoantimicrobial	54 (84)	23 (72)
Polyantimicrobial	10 (16)	9 (28)
Min, Max	1, 2	1, 2
Length of Course (Days)		
Median	37	39.5
Min, Max	1, 61	9, 74

Due to rounding, percentages may not add to 100.0
Due to missing data, row totals may not add to N

Table 11. Outcomes of OPAT course of 97 MSK patients

	64 Patients with no OPAT Alteration N (%)	32 Patients with OPAT Alteration N (%)
Did Patient Receive Follow-up Within 30 Days of Starting OPAT	44 (69)	24 (75)
Did Patient Experience an ADE	7 (11)	7 (22)
Was Surgical Debridement Performed?	27 (42)	18 (56)
Evidence of Clear Margins after Debridement		
Yes	8 (13)	5 (16)
No	14 (22)	7 (22)
Unknown	4 (6)	6 (19)
Did Patient have Evidence of Resolution Within 6 Months of Completion of OPAT Course?	43 (67)	16 (50)
Was OPAT Course >= 5 Weeks	44 (69)	23 (72)

Due to rounding, percentages may not add to 100.0
Due to missing data, row totals may not add to N

Table 12. Univariate association between select factors and failure to resolve infection through OPAT among 64 MSK patients with no alteration in their OPAT course

Patient Factors	RR (95% CI)	P-Value
Tobacco Use	0.44 (0.12-1.63)	0.22
Alcohol Use Disorder	1.27 (0.78-2.06)	0.34
Illicit Drug Use	1.26 (0.76-2.09)	0.36
Age ≥ 60	0.78 (0.38-1.62)	0.51
Number of Mental Health Diagnoses	1.15 (0.43-3.07)	0.77
Incident Hospitalization		
Surgical Debridement	0.52 (0.21-1.31)	0.17
Length of Hospitalization	1.00 (0.92-1.10)	0.91
Select CCI Factors		
Chronic Lung Disease	0.41 (0.11-1.55)	0.19
Hemiplegia	1.61 (0.66-3.91)	0.29
Diabetes	1.50 (0.67-3.34)	0.32
Cerebrovascular Disease	1.58 (0.55-4.50)	0.39
Congestive Heart Failure	1.36 (0.53-3.46)	0.52
Severe Diabetes	1.10 (0.54-2.21)	0.80
Chronic Liver Disease	0.86 (0.25-2.93)	0.81
Microorganism		
Other Coagulase Negative *Staphylococcus**	2.54 (1.36-4.76)	0.004
Enterococcus	0.74 (0.21-2.58)	0.63
Proteus	0.86 (0.25-2.93)	0.81
MSSA	0.94 (0.41-2.15)	0.88
Unknown	1.02 (0.42-2.48)	0.97
Condition		
Diabetic Foot Infection	0.35 (0.05-2.26)	0.27
Bone Infection	1.25 (0.62-2.51)	0.54
Prosthetic Infection	1.03 (0.50-2.11)	0.95
Hospital IV Drugs		
Vancomycin*	0.48 (0.24-0.97)	0.04
Beta-lactams	0.39 (0.15-1.03)	0.06
Cephalosporins	0.78 (0.44-1.38)	0.40
Daptomycin	1.36 (0.53-3.46)	0.52
Carbapenems	0.86 (0.25-2.93)	0.81
1st OPAT Course		
Cephalosporins	1.51 (0.74-3.08)	0.26
Carbapenems	0.41 (0.06-2.59)	0.34
Beta-lactams	0.64 (0.18-2.30)	0.50
Daptomycin	1.23 (0.55-2.72)	0.62
Vancomycin	1.02 (0.38-2.76)	0.97
OPAT course ≥ 5 Weeks	1.45 (0.62-3.42)	0.39
Patient Follow-up Status	0.91 (0.43-1.90)	0.80

Presence of an ADE during OPAT Course	0.86 (0.25-2.93)	0.81

* Denotes a statistically significant finding
Due to rounding, percentages may not add to 100.0
Due to missing data, row totals may not add to N

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