BRIEF REPORT

# Safety of Peripherally Inserted Central Catheter Use in Children From Rural Versus Urban Settings Receiving Long-term Parenteral Antimicrobial Therapy

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ABSTRACT

**OBJECTIVES:** To determine the safety of peripherally inserted central catheter (PICC) use for delivery of outpatient parenteral antimicrobial therapy (PAT) in children discharged to rural or urban locales. We hypothesized that children from rural settings would experience higher complication rates.

**PATIENTS AND METHODS:** We conducted a retrospective cohort study of children admitted to an academic medical center in the Southwestern United States over 9 years who were discharged with a PICC to complete a course of PAT with follow-up at our institution. To classify rural versus urban residence, we used rural-urban continuum codes from the US Department of Agriculture, the driving time in hours to the nearest trauma center, and the discharging center using Google Maps.

**RESULTS:** In total, 221 children met inclusion criteria (mean age 9.8 years). Osteoarticular infections and cystic fibrosis exacerbations were the most common indications for PICC use (68.8%). The mean driving time to the discharging hospital was significantly longer for those children residing in the most rural regions of the state (3.6 vs 0.8 hours; $P < .001$) as well as to the nearest level 1, 2, or 3 trauma center (2.2 vs 0.4 hours; $P < .001$). PICC complications occurred in 47 children (21.3%). No association was found between rural-urban continuum codes, driving times to the discharging hospital, or nearest trauma center with any complication nor with complications overall.

**CONCLUSIONS:** In our study, we demonstrate an equivalent safety profile for children in rural and urban settings with PICCs for receipt of outpatient PAT.

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Ms Beachum helped conceptualize the study, designed the data collection instrument, and collected data; Dr Dehority helped conceptualize the study and collected and analyzed the data; and all authors wrote and revised the manuscript and approved the final manuscript as submitted.

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Treatment of severe infections in children often requires prolonged intravenous antibiotic use. Peripherally inserted central catheters (PICCs) facilitate such treatment given their potential for home use, and they have become standard of care for prolonged parenteral antimicrobial therapy (PAT) at many institutions.[1,2] Outpatient PICC use is more cost-effective than hospitalization and has comparable outcomes.[3,4] Unfortunately, children may develop complications associated with a PICC, including displacement and/or malfunction (6%–37%), leakage (2%–11%), occlusion (4%–34%), premature removal (>33%), and bloodstream infections (>15%).[1,4–9]

Though studies have demonstrated the safety and efficacy of PICC use in children, none have studied outpatient rural use. However, adverse health outcomes are more frequent in rural populations.[10,11] Children from rural settings are more likely to require readmission after hospitalizations and to reside in areas lacking social and/or physical resources than their urban counterparts, and they are less likely to belong to a medical home.[11,12] Given the lack of data on rural PICC use as well as the rural nature of our state, we studied the safety of home PICC use for treating infections in children in rural settings. We hypothesized that children from rural locales would have higher complication rates than those in urban settings.

## METHODS

### Study Design

We conducted a retrospective cohort study of children <18 years of age discharged from an academic medical center in the Southwestern United States with a PICC placed for outpatient PAT. Patients were admitted between January 1, 2005, and March 1, 2014. We identified patients through analysis of 43 different *International Classification of Diseases, Ninth Revision* and *Current Procedural Terminology* codes indicative of PICC placement, with analysis of the electronic medical record (EMR) to identify patients discharged on PAT with a PICC. In addition, participants were required to have follow-up at our institution and complete information on outcome through PICC removal. We recorded demographic data, antibiotic(s) used, duration and indication for the PICC, and type and timing of complications. To classify rural versus urban residence from the zip code in the EMR, we used rural-urban continuum codes (RUCCs) from the US Department of Agriculture.[13] RUCCs are a validated classification scheme used to categorize counties into 9 groups by degree of urbanization, size, and proximity to a metropolitan area (Table 1).[14–16] The driving times in hours and miles to the nearest level 1, 2, or 3 trauma center and our institution were calculated by using Google Maps and the patients' addresses in the EMR. All patients had either weekly home health or clinic visits. Patients were given a 24-hour contact number for on-call pediatric infectious disease physicians. All data were entered into a research electronic data capture platform hosted at our university.[17]

### Power Calculations

On the basis of review of 7 publications in which researchers summarize complication rates with pediatric PICCs,[1,4–9] we anticipated a complication rate of 35.4%. Assuming an SD of 0.474 (from a previous study of PICC use for PAT)[7] and a 2-sided $\alpha$ of .05, we anticipated 178 participants were necessary to demonstrate with 80% power a statistically significant difference of 20% between rural and urban patients.

### Statistical Methods

For direct comparison of demographic features and adverse outcomes, participants were dichotomized into residence in more urban regions (RUCCs 1–3) and residence in more rural regions (RUCCs 4–9), an approach validated in the literature.[14] Welch's *t* test was used for tests of statistical significance (*P* value <.05 considered significant). With linear and logistic regression models, we assessed for differences between outcome and response variables across all RUCCs as a whole. This project was approved by our human research review committee (#15-576).

## RESULTS

Eight hundred and sixty-six patients were identified, accounting for 1066 PICC placements. Of these, 845 placements were ineligible for inclusion, leaving 221 PICC placements in 184 patients meeting inclusion criteria (Fig 1). The maximum number of separate PICC placements in 1 patient was 5, with 37 patients receiving >1 PICC for separate courses of outpatient PAT.

The mean age of eligible participants was 9.8 years (median 10.3 years, interquartile range [IQR] 5.3–14.0 years), with 60.6% boys. No significant differences between the rural and urban cohorts were noted for any clinical or demographic variables, including duration of PICC use (Table 2). The most common indications for PAT were osteoarticular infections (57.9%) and cystic fibrosis exacerbations (23.5%). The most common antibiotics used were tobramycin (25.3%), nafcillin (24.7%), and cefazolin (20.4%). PICCs were used for a mean of 26.1 days at home (median 25 days, IQR 13–37 days). The mean driving distance from our institution was 76.7 miles (median 27.8 miles, IQR 9.7–138 miles, maximum 317 miles), with a mean driving time of 1.3 hours (median 0.6 hours, IQR 0.33–2.3 hours, maximum 10.3 hours). The mean driving distance to the nearest level 1, 2, or 3 trauma center was 26.7 miles (median 12 miles, IQR 6.5–30.5 miles, maximum 170 miles), with a mean driving time of 0.6 hours (median 0.4 hours, IQR

**TABLE 1** Distribution of RUCCs

| | RUCC | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| No. participants | 0 | 122 | 38 | 9 | 21 | 15 | 13 | 0 | 3 |

The RUCCs are as follows: 1, MA ≥1 000 000; 2, MA 250 000–1 000 000; 3, MA ≤250 000; 4, UP ≥20 000 and adjacent to MA; 5, UP ≥20 000 and not adjacent to MA; 6, UP 2500–19 999 and adjacent to MA; 7, UP 2500–19 999 and not adjacent to MA; 8, rural or ≤2500 UP and adjacent to MA; and 9, rural or ≤2500 UP and not adjacent to MA. MA, metropolitan area; UP, urban population.

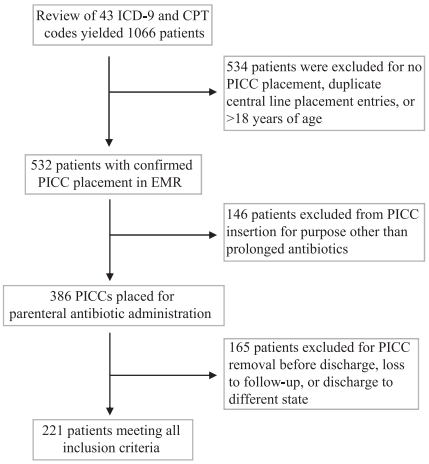


**FIGURE 1** Flowchart of included study participants. CPT, *Current Procedural Terminology*; *ICD-9*, *International Classification of Diseases, Ninth Revision*.

0.27–0.6 hours, maximum 10.3 hours). The distribution of RUCCs for our cohort is listed in Table 1. Patients from the most rural areas (RUCCs 7–9) had mean driving times to our institution of 3.6 hours, significantly longer than the driving times for the most urban cohorts (RUCCs 1–3, 0.8 hours; $P < .001$) and for those residing in rural cohorts represented by RUCCs 4 to 6 (3.6 vs 2.8 hours; $P < .001$). Similarly, driving times for this most rural cohort to the nearest level 1, 2, or 3 trauma center were longer when compared with those residing in regions denoted by RUCCs 1 to 3 (2.2 vs 0.4 hours; $P < .001$) and RUCCs 4 to 6 (2.2 vs 0.7 hours; $P < .001$).

Forty-seven PICC-related adverse events (AEs) occurred (21.3% of patients with 7.4 events per 1000 days of PICC use), with occlusion and accidental removal (28.3% of PICC-related AEs each) most common. PICC-related AEs occurred at a mean of 24.7 days after insertion (median 24.5 days, IQR 14.8–34.0 days). Accidental PICC removal (by the patient) occurred in 12 patients (5.4%), with premature medical removal (by the provider) in 28 patients (12.7%) and occlusion of the PICC in 13 patients (5.9%). The frequency of PICC-associated complications did not vary by RUCC nor driving time to our hospital or the nearest trauma center in regression models ($P = .077$–$.847$). Thirty-three antimicrobial AEs were reported, with diarrhea (27.3% of antimicrobial-related AEs) and neutropenia (51.5% of antimicrobial-related AEs) most common.

When compared with patients residing in the most urban regions (RUCCs 1–3), patients in the most rural regions (RUCCs 7–9) did not demonstrate any variance in the frequency of antimicrobial AEs (7.7% vs 19.5%; $P = .092$), PICC complications (20.0% vs 22.7%; $P = .408$), nor time to onset of PICC complications (24.3 vs 25.3 days; $P = .378$).

Rural residence did not appear to affect the decision to discharge a patient with a PICC, nor was it associated with loss to follow-up, both of which could produce selection biases. Rural residence (RUCCs 4–9) among the 95 patients excluded from our analysis who had a PICC placed but were not discharged was 33.7%, which is not significantly different from the frequency of rural residence in the cohort discharged with a PICC overall (31.6%; $P = .363$). In addition, no significant difference was found between the percentage of rural patients lost to follow-up (31.6% of the 26 patients lost to follow-up) and rural patients with follow-up who were included in the analyses (34.6%; $P = .384$).

**TABLE 2** Demographic Distribution of 221 Children Treated With Outpatient PAT With a PICC

| Variable | RUCCs 1–3[a] | RUCCs 4–9[a] | *P* |
|---|---|---|---|
| Age, y | 9.8 | 9.8 | .464 |
| Boys, % | 63.8 | 52.5 | .067 |
| Ethnicity, % | | | |
| Hispanic | 26.9 | 35.0 | .144 |
| Not Hispanic | 41.9 | 36.1 | .215 |
| Not stated | 31.3 | 29.5 | .401 |
| Driving time to discharging hospital, h | 0.8 | 2.8 | <.001 |
| Driving time to nearest level 1, 2, or 3 trauma center, h | 0.4 | 1.1 | <.001 |
| Duration of PICC use, d | 31.2 | 31.1 | .485 |
| Duration of home PICC use, d | 25.9 | 26.5 | .422 |
| Acute osteomyelitis, % | 26.3 | 26.3 | .499 |
| Chronic osteomyelitis, % | 22.5 | 21.3 | .425 |
| Cystic fibrosis exacerbation, % | 21.3 | 29.5 | .111 |

[a] RUCCs 1 through 3 represent counties in metropolitan areas while RUCCs 4 through 9 represent counties in non-metropolitan areas as defined in the footnote of Table 1.

## DISCUSSION

We believe our study is the first in which the safety of PAT with a PICC in children discharged to rural locales is assessed. We did not observe any variance in complication rates related to rural or urban residence, consistent with a recent study of PICCs in adults.[18] These findings persisted when rural status was assessed in a dichotomous fashion and a regression model across all RUCCs. The overall complication rate for our patients was 21.3%, which is consistent with previous reports.[1,4–9] The mean time of onset for complications after PICC insertion in our cohort was 24.7 days, which is later in the course of therapy than previously reported.[5–9] Our urban and rural cohorts were similar in composition to each other, which makes demographic and clinical differences an unlikely explanation for our findings. In addition, the duration of PICC use (an independent risk factor for complications)[19,20] did not differ between the cohorts, nor was there a differential loss to follow-up or differential discharge rate among rural compared with urban patients.

Our study's biggest limitation was a lack of access to medical records outside our system. Complications seen at outside hospitals would not be documented in our EMR, which would serve to underestimate the frequency of complications in the rural

cohort. In addition, geographic and climatic differences between states may affect the generalizability of our results.

In our study, we did not find any difference in complication rates among children living in rural or urban settings receiving outpatient PAT with PICCs. In future studies, researchers should identify methods to decrease complication rates and decrease the need for PICC use (eg, earlier transition to oral therapy).

## CONCLUSIONS

In our study, we demonstrate an equivalent safety profile for outpatient PAT with PICCs in selected children who reside in rural and urban areas. Our study may be applicable to other rural states where patients frequently reside far from higher levels of care.

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