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Suboptimal HIV Testing Among Patients Admitted with Pneumonia: A Missed Opportunity

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Abstract

Patients admitted with pneumonia are at higher risk for HIV and should be routinely screened. We examined a retrospective cohort of patients admitted to Duke University Health System with a primary diagnosis of pneumonia. During the study period, 6,951 persons were admitted with pneumonia. Of 6,646 patients without a known prior diagnosis of HIV, 1,010 (15%) had HIV testing during admission and 1,516 (23%) had a previously documented HIV test result. 41 (0.6%) patients had a positive HIV test during admission and 27 (0.4%) patients were diagnosed with HIV a median of 498 (IQR 112–982) days later, with median CD4 count of 64 (IQR 16–281) cells/mm³. HIV testing rates remain low in a population at high risk for HIV. At a minimum, we should be adhering to universal HIV screening recommendations, and certainly we should be screening those at higher risk. Opt-out HIV testing of pneumonia inpatients should be implemented.

Keywords

human immunodeficiency virus; screening; pneumonia; quality improvement

Introduction

In the United States, there are close to 40,000 new human immunodeficiency virus (HIV) infections each year (Centers for Disease Control and Prevention, 2016) with recent estimates that 13–18% of those living with HIV are undiagnosed (Hall et al., 2015; Skarbinski et al., 2015). Of those newly diagnosed with HIV infection, 41% report no prior HIV testing and approximately one-third are diagnosed late, meaning acquired immunodeficiency syndrome (AIDS) diagnosed within 12 months of initial HIV diagnosis (Centers for Disease Control and Prevention, 2010, 2012). Lack of awareness of HIV status not only can contribute to morbidity and mortality, but also leads to increased transmission

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rates. An estimated 30% of new HIV transmissions are attributed to undiagnosed HIV infection (Skarbinski et al., 2015).

Early screening and diagnosis of HIV infection can improve outcomes (Centers for Disease Control and Prevention, 2010; Moyer, 2013; Sanders et al., 2005). Since 2006, the Centers for Disease Control and Prevention (CDC) has recommended universal HIV screening in all health care settings for patients aged 13 to 64 years, even in areas with relatively low HIV prevalence (Branson et al., 2006). Routine HIV screening has been shown to be cost-effective (Paltiel et al., 2005; Sanders et al., 2005; Walensky, Freedberg, Weinstein, & Paltiel, 2007), with testing at time of inpatient admission more cost effective in quality-adjusted life-years than routine screening programs for diseases such as colon cancer, breast cancer, and diabetes (Walensky et al., 2007).

Implementation of opt-out HIV testing in the Emergency Department can increase HIV testing and subsequent diagnosis rates (Haukoos et al., 2010; Hoxhaj et al., 2011). A recent randomized clinical trial showed that opt-out testing increased HIV testing rates compared to other methods (Montoy, Dow, & Kaplan, 2016). Despite universal screening recommendations in all health care settings, data evaluating HIV screening in the inpatient setting are relatively sparse. HIV screening focused primarily on Emergency Department patients awaiting hospital admission demonstrated that new diagnoses of HIV infection had more advanced disease (Lubelchek, Kroc, Levine, Beavis, & Roberts, 2011). A pilot study in a hospital in England showed increased HIV testing rates and subsequent HIV diagnosis with the introduction of routine HIV screening for all medical admissions; however, HIV testing rates remained low with less than one-quarter of eligible patients HIV tested (Palfreeman et al., 2013).

Bacterial pneumonia is one of the most common infections among HIV-infected individuals in developed countries, particularly in the era of effective anti-retroviral therapy and routine prophylaxis against pneumocystis pneumonia (Benito, Moreno, Miro, & Torres, 2012; Feldman & Anderson, 2013). Compared to HIV-uninfected persons, those with HIV are at higher risk for bacterial pneumonia regardless of CD4 count (Hirschtick et al., 1995). Conversely, patients with bacterial pneumonia are more likely to have underlying HIV infection compared to patients without bacterial pneumonia, with a study showing bacterial pneumonia as the strongest indicator condition associated with HIV infection of those evaluated (OR 47.7, 95% CI 5.6–404.2) (Damery et al., 2013). Additionally, a diagnosis of bacterial pneumonia is a predictor of known HIV infection and previously undocumented or unknown HIV infection (Owens et al., 2007). Clinical manifestations of bacterial pneumonia are very similar among HIV-infected compared to HIV-uninfected individuals, making it difficult to selectively screen patients for HIV upon presentation to the hospital with pneumonia (Benito et al., 2012; Feldman & Anderson, 2013).

There is a paucity of data on HIV testing among patients admitted with pneumonia, a higher risk population. In the United Kingdom (UK) an opt-out approach to HIV testing substantially increased HIV testing rates in a cohort of patients admitted to a general medicine service with lobar pneumonia, although overall HIV testing rates remained low (Wallis, Thornhill, Saunders, & Orkin, 2015).

Given the ease and cost-effectiveness of HIV screening and increased risk of HIV infection in those with bacterial pneumonia, our study aimed to examine trends in HIV testing among inpatients with pneumonia as well as missed opportunities for HIV diagnosis.

Methods

We performed a retrospective cohort study of patients presenting to Duke University Health System (DUHS), which consists of a tertiary care hospital and two community hospitals. Patients who presented to DUHS between July 1, 1996 and December 31, 2014 with a primary diagnosis of pneumonia were included in the study. Only the first episode of pneumonia was included in the analysis. Patients were excluded if they were less than 18 years or greater than 64 years of age. The cohort was assembled using the Duke Enterprise Data Unified Content Explorer (DEDUCE) tool, which is an interface used to extract data from the electronic medical record (Horvath et al., 2011). DEDUCE is a research tool that interfaces with our system's electronic medical records, permitting extraction of demographic, laboratory, radiographic, and administrative (e.g. ICD-9 and CPT codes) data for patients who receive care in our health system. Data for Duke University Hospital were available dating from July 1, 1996, while data from the community hospitals, Duke Regional and Duke Raleigh, were available starting in 1996 (complete data starting 1998) and 2000 (complete data starting 2001), respectively.

Primary diagnosis for pneumonia was determined based on admission diagnosis using the International Classification of Diseases, Ninth Revision (ICD-9) codes (481.xx, 482.xx, 483.xx, 485.xx, 486.xx), similar to prior studies (Kaplan et al., 2002; McGregor et al., 2005; Restrepo, Mortensen, Velez, Frei, & Anzueto, 2008; van de Garde, Oosterheert, Bonten, Kaplan, & Leufkens, 2007). Based on the diagnosis codes included, ventilator-associated pneumonia and aspiration pneumonia were not included. We validated a diagnosis of pneumonia by randomly sampling 100 patients and reviewing their electronic medical records. We used two criteria to define a validated diagnosis of pneumonia: 1) Meeting the CDC definitions for pneumonia (Horan, Andrus, & Dudeck, 2008), or 2) Presence of a stated diagnosis of pneumonia in either the admission note or discharge summaries. The second criterion was included with the rationale that if the admitting or discharging clinician thought that the patient had pneumonia, HIV testing should have been performed regardless of whether the diagnosis of pneumonia met a standard definition.

The primary outcome was the presence of HIV testing during the pneumonia admission, which was defined as HIV testing the day prior to admission through 14 days after admission or length of stay, whichever was longer. This defined time period accounts for those tested in the outpatient clinic immediately prior to admission, those who refused testing and/or were tested just after discharge from a relatively shorter hospital stay, and thus likely related to the pneumonia admission. To evaluate the prevalence of HIV testing in our cohort, we first excluded patients with a known HIV diagnosis prior to pneumonia admission. We then utilized current procedural terminology (CPT) codes to define HIV testing. Due to the use of administrative data, a simple random sample of the cohort was used to validate HIV testing. This validated sample also included evaluating for HIV testing that was documented in the medical record but did not occur in our health system. For this

process, we utilized the search function in our electronic medical record system, which finds progress notes and labs associated with “HIV”. Once the search function found the associated notes and labs, the HIV test was verified by looking at the appropriate section. A reviewer performed this process manually and reviewed a second time to ensure accuracy. For simplicity, we defined the pre-guideline era as prior to January 1, 2007, and the post-guideline era as on or after January 1, 2007.

Secondary outcome was new HIV diagnosis during or following pneumonia admission. HIV diagnosis for the cohort was ascertained by searching for CPT codes for HIV testing and ICD-9 codes for HIV infection (V08, 042) in relation to first pneumonia admission. The electronic medical records for patients identified with subsequent new HIV diagnoses using administrative data were manually reviewed to confirm that the HIV diagnosis was new and was not known before the time of pneumonia admission. All new HIV diagnoses manually verified were confirmed HIV positive with a laboratory test.

We characterized the population of admitted pneumonia patients during the study period. We determined HIV testing rates and HIV status. Chi-square test with continuity correction was used to compare proportions. Time series analysis was used to examine trends in HIV testing over time. All analyses were performed using SAS statistical software version 9.4 (Cary, NC) and R version 3.3.1 (R core team 2016). This study was exempt by the Institutional Review Board at Duke University Hospital as a quality improvement project to improve HIV testing and diagnosis rates within our health system.

Results

Demographics

During the study period, 6,951 persons were admitted to the health system with a primary diagnosis of pneumonia (Table 1). Patients were of median age 50 years, approximately half men (51%), and predominately Caucasian (53%) or African American (41%). The majority of patients (59%) were admitted to Duke University Hospital (tertiary care center); all others were admitted to community hospitals. Approximately half (49%) of patients were admitted in the pre-guidelines period (2006 or before). A total of 305 patients (4.4%) were known to be HIV positive at time of admission.

HIV testing

There were 6,646 patients without known HIV infection admitted with pneumonia. During pneumonia admission, 1,010 (15%) patients underwent HIV testing (Figures 1 and 2). Of the cohort HIV tested during pneumonia admission, 185 (18%) had prior HIV testing, with 49 (4.9%) in the year prior to admission. In terms of specific hospital, 590 (15%) admitted to DUH were tested for HIV during admission, compared to 288 (16%) at DRH and 132 (14%) at DRAH ($p = 0.36$ for difference in testing rates by hospital). HIV testing was evaluated prior to admission as well (Figure 2).

We evaluated whether HIV testing rates changed after the CDC recommendation for universal HIV testing in 2006. Before guidelines were published, 534 (16%) had ever been tested for HIV prior to admission (7.4% within a year prior to admission), with an increase

to 982 (29%) patients post-2006 (11% within a year prior to admission) ($p < 0.0001$ for both testing prior to admission and within a year prior to admission). Testing rates during admission also increased with 445 (14%) of patients tested for HIV during pneumonia admission in 2006 and earlier compared with 559 (16%) post-2006 ($p = 0.002$). Of note, testing rates declined in 2013 and 2014 compared with prior years, coincident with implementation of a new electronic medical record system.

HIV diagnosis

During pneumonia admission, 41 (0.6%) patients had a new HIV positive test result, corresponding with a 4.1% HIV positivity rate for those HIV tested during admission (Figure 2). Another 27 patients (0.4%) who were not HIV tested during admission were subsequently diagnosed with HIV a median of 498 (IQR 112–982) days after pneumonia admission. Of 22 patients with available laboratory data, the median CD4 count at time of HIV diagnosis following pneumonia admission was 64 (IQR 16–281) cells/mm³.

Validation

To validate the HIV testing rates obtained from CPT code data, we performed manual electronic medical record review of a simple random sample of 207 patients without a prior diagnosis of HIV. Of this sample, 45 (22%, 95% CI 16–27%) had an HIV test before admission, either noted by laboratory testing in our health system or performed outside our health system and documented in the medical record, similar to the 18% captured by CPT coding and within the confidence interval range. While most HIV testing was performed in our system, 10 (5.0%) patients had prior HIV testing documented in the medical record performed outside our health system. During admission, 34 patients (16%, 95% CI 11–22%) had HIV testing.

To validate timing and accuracy of HIV diagnosis as assessed by ICD and CPT code data, we performed a manual chart review (Table 2). A number of new HIV diagnoses as described were coded into different timing categories, including some miscoded and HIV negative. We utilized actual timing of HIV diagnosis based on manual chart review for the analysis given the inaccuracy of the coding data.

To validate the diagnosis of pneumonia, we randomly selected 100 patients from our cohort. There were 98 electronic medical records available for review. Of these 98 patients, 52 (53%) met the CDC criteria for pneumonia. Furthermore, 90 (92%) of patients had a stated diagnosis of pneumonia either in the admission or discharge summary.

Discussion

HIV testing rates in this high-risk population of patients admitted with pneumonia remain disappointingly low despite publication of the CDC guidelines for universal HIV screening. Only 15% of pneumonia patients aged 18 to 64 years in our cohort were tested for HIV during the pneumonia admission, despite the fact that more than three-quarters of the cohort did not have a prior HIV test result documented in the electronic record. Unfortunately, although CDC guidelines for universal HIV screening published in 2006 had an effect on testing rates, the overall rates remain poor. There was a recent notable decline in HIV testing

rates coincident with the implementation of a new electronic record in our health system. Potential causes for this decline include the complexity of learning a new system and associated distractibility. Additionally, HIV testing was in the pneumonia admission orderset for a period of time prior to the new system, although given persistently low testing rates, it is clear that this was not used consistently. Given the overall poor HIV testing rates over the study period, we did not further classify HIV testing rates by demographic variables or other risk factors for HIV infection.

Patients admitted with pneumonia in our health system had a high prevalence of HIV. Among admitted patients, we found 4.4% had a prior diagnosis of HIV infection, almost a 10-fold higher prevalence compared to the general population in the United States (Hall et al., 2015). In addition, of the 1,010 patients that were HIV tested during admission, the HIV positivity rate was 4.1%. There were higher proportions of new HIV diagnoses among those without any prior HIV testing, compared to those with prior negative HIV testing ever in the system or within the 1 year prior to admission, suggesting those without any prior HIV testing in the system should be more aggressively targeted for HIV testing during pneumonia admission.

Our findings are consistent with previous studies showing that patients with pneumonia should be considered high risk for HIV infection.(Damery et al., 2013; Owens et al., 2007) Since routine HIV testing has been shown to be cost-effective in populations with an HIV prevalence as low as 0.1% (Sanders et al., 2005), our data suggest that universal HIV testing of patients admitted with pneumonia would be cost-effective and high-yield. This finding has been formally recognized in other settings; for example, in the United Kingdom, National HIV Testing Guidelines recommend HIV screening for any patient with bacterial pneumonia (British HIV association, British Association of Sexual Health and HIV, & British Infection Society, 2008).

A number of persons were diagnosed with HIV after a prolonged delay (median 498 days) from pneumonia admission. Although it is possible that some of these patients may have contracted HIV in the time interval between admission and HIV diagnosis, we suspect that in most cases the failure to perform HIV testing during admission was a missed opportunity for earlier HIV diagnosis, particularly given the high prevalence of advanced HIV in this group (median CD4 count of 64 cells/mm³) at the time of eventual diagnosis. Furthermore, this number may underestimate subsequent HIV diagnoses, as some patients were not followed in our healthcare system and may have been diagnosed with HIV elsewhere. These delayed diagnoses represent missed opportunities and highlight the importance of HIV screening to improve clinical outcomes and to prevent HIV transmission, as almost one-third of new HIV transmissions are attributed to undiagnosed HIV infection (Skarbinski et al., 2015).

There are limitations to our study. This is a retrospective, single health system study, which may limit generalizability of our results. There is a potential for misclassification and under-ascertainment of testing based on the use of an administrative database. However, the manual record review of a randomized sample of subjects should have mitigated this problem. We noted that some subjects for prior HIV testing were documented as tested

outside of the system; however, we had similarly low testing rates in the random sample, suggesting that our results were robust, even with the use of the administrative data.

There is not much known about the use of administrative data to capture HIV diagnosis and we noted discrepancies in ICD-9 coding for HIV diagnosis and actual HIV infection. A step-wise algorithm for capturing HIV diagnosis utilizing a combination of administration and lab data demonstrated 83% sensitivity and 85% positive predictive value of determining new HIV diagnosis (Goetz, Hoang, Kan, Rimland, & Rodriguez-Barradas, 2014). Given the limited data on using HIV diagnosis in an administrative database, we validated each HIV diagnosis coded by DEDUCE as HIV positive, evaluating both accuracy and timing.

There is a concern that using ICD codes to identify pneumonia patients may have misclassified patients who did not truly have pneumonia; however, other studies have demonstrated that ICD-9 code algorithms have a reasonably high specificity for pneumonia diagnosis (Aronsky, Haug, Lagor, & Dean, 2005; van de Garde et al., 2007). We also performed medical record review on a random sample of our population and demonstrated that providers had clinically diagnosed most of these patients with pneumonia, and therefore should have screened for HIV.

More studies are needed to evaluate HIV testing and diagnosis in this high-risk population of patients admitted with pneumonia. There are few studies looking at this issue. At a minimum, we should be adhering to the universal screening recommendations for HIV testing, and certainly we should be screening those considered at high-risk, which includes those admitted with pneumonia. Unfortunately, it appears that publication of the guidelines alone clearly did not produce a major effect on inpatient HIV testing rates. Other changes such as eliminating the need for written informed consent in North Carolina (North Carolina Department of Public Health, 2007) and presumed increased provider awareness of HIV infection and screening guidelines over time also did not seem to have had major effects on inpatient HIV testing rates in this high risk population. Potential interventions to increase routine HIV testing of high-risk populations in the hospital clearly need to be further studied. Implementation of a new electronic medical record system in 2013 seemed to be associated with a decline in HIV testing rates; it is our hope that systematic changes within that system may reverse that decline. Effective strategies have been shown for an inpatient hepatitis C screening program in Texas (Turner et al., 2015); however, there were difficulties with participation for an opt-out HIV testing program in a hospital in Singapore (Chua et al., 2012). HIV screening led by nurses compared to physicians improved HIV testing rates, indicating another potential modality to improve HIV testing rates (Anaya et al., 2008). The use of electronic alerts for HIV testing has also been shown to improve testing rates, compared to no alert (Czarnogorski et al., 2013; Felsen et al., 2016). A recent randomized clinical trial showed that opt-out HIV testing methods increases HIV testing rates compared to other methods (Montoy et al., 2016). It seems that a combination of an opt-out approach together with the utilization of electronic record alerts may be needed to improve inpatient HIV testing rates. At our institution, we plan a multi-pronged intervention to improve HIV testing rates in this higher risk population. We have disseminated the results of our study to raise awareness of the problem. We will then work with information technology to implement solutions within the electronic medical record. Our first step will be to create an

automated electronic alert recommending screening for HIV in persons with an admitting diagnosis of pneumonia and who have not had prior HIV testing documented in our health system. We will evaluate the efficacy of these alerts using quality improvement methods, which will help inform future interventions to improve inpatient HIV screening rates in pneumonia inpatients. The eventual goal will be to improve HIV screening rates of all patients admitted to the hospital, not just those at higher risk for HIV infection.

Conclusions

Given the cost-effectiveness of inpatient HIV screening (Walensky et al., 2007), the knowledge that early HIV diagnosis improves outcomes (Centers for Disease Control and Prevention, 2010; Moyer, 2013; Sanders et al., 2005), and the overall low HIV screening rates found in our study in this high-risk population, we recommend opt-out HIV testing for all patients admitted to the hospital with pneumonia. Ongoing monitoring of HIV testing rates in high-risk inpatient populations and systematic examination of strategies to improve universal testing will be vital to reducing delays in HIV diagnosis and resultant morbidity and mortality.

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Figure 1:
Time series analysis, HIV testing among patients admitted to Duke University Health System with a primary diagnosis of pneumonia, 1996–2014.

Figure 2.

HIV testing and diagnosis among patients admitted to Duke University Health System with a primary diagnosis of pneumonia, 1996–2014.

- A. Overall depiction of HIV testing and diagnosis among patients.
- B. HIV testing and diagnosis among patients without prior HIV testing.
- C. HIV testing and diagnosis among patients with prior HIV testing.

Table 1.

Demographics of patients admitted to Duke University Health System with a primary diagnosis of pneumonia, 1996–2014.

Characteristic	Patients with first primary diagnosis of pneumonia (N = 6951)
Age in years, median (IQR)	50 (40–58)
Sex, number (%)	
Men	3446 (50)
Women	3505 (50)
Race, number (%)	
Caucasian	3696 (53)
African American	2853 (41)
Asian	48 (0.7)
Native American or Alaskan Native	33 (0.5)
Native Hawaiian or Other Pacific Islander	1 (0.0)
Multiracial	79 (1.1)
Other or Unknown	241 (3.5)
Hospital, number (%)	
Duke University	4082 (59)
Duke Regional	1872 (27)
Duke Raleigh	997 (14)
Discharge service, number (%)	
Internal Medicine	4282 (62)
Pulmonary	634 (9.1)
Other	2035 (29)
Timing of admission, number (%)	
1996–2006	3388 (49)
2007–2014	3563 (51)
HIV diagnosis at admission, number (%)	305 (4.4)

Table 2.

Accuracy and timing of HIV diagnosis based on data from the administrative database by validated manual chart review, in relation to pneumonia admission, 1996–2014.

Validated HIV diagnosis	Administrative database timing of HIV diagnosis			Total Validated HIV+
	Before	During	After	
Before	276	24	5	305
During	7	23	11	41
After	0	0	27	27
Miscoded, HIV negative	18	3	14	35
Unknown	2	0	7	9