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Research review

Medication Reconciliation and Patient Safety in Trauma: Applicability of Existing Strategies

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ABSTRACT

The Joint Commission has established medication reconciliation as a National Patient Safety Goal, but it has not been studied much in trauma even though it is integral to safe patient care. This article reviews the existing medication reconciliation strategies and their applicability to the trauma setting. To perform medication reconciliation, hospitals use a variety of strategies including pharmacists or pharmacy technicians, electronic medical record tools, and patient-centered strategies. All of these strategies are limited in trauma. Subpopulations such as injured children, the elderly, and those with brain trauma are particularly challenging and are at risk for suboptimal care from inaccurate medication reconciliation. Further research is necessary to create a safe and efficient system for trauma patients.

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Introduction

The Joint Commission made medication reconciliation a requirement in 2006 based on its critical importance to clinical decision-making.[1] The FDA regulates nearly 1500 prescription medications in the United States today and clinicians can put patients needlessly at risk without an accurate sense of which medications they are on. Suboptimal medication reconciliation risks adverse drug events, complications, and readmissions.[2,3] In fact, 50% of medication errors occur at admission, transitions of care, and discharges. An adverse drug event results in an average increase in length of stay of over 2.2 d and at an associated cost of at least $2595 per event.[4]

Medication reconciliation is a complex process involving multiple steps. The first step involves obtaining and verifying a current medication list with a second source if needed, such as the patient's pharmacy. Second, the medications and doses are clarified as appropriate, and then third, these are incorporated into the patient's current clinical treatment.[5] The process involves many people including the patient, family member(s), or other caregiver(s), nurse(s), social worker(s), case manager(s), pharmacist(s), physician(s), and other staff and is susceptible to errors at every step.[6]

For example, it may not be possible to obtain a current medication list or the name of pharmacy or primary care physician from an incapacitated patient or uninformed family. Verifying information may be difficult if patients use alternative sources of medications such as online pharmacies or if patients are from other health systems. Even if patients are able to provide information, they may not be able to clarify which medications they took or when, or the dose and indication, because they may be incoherent or incapacitated. Therefore, the accuracy of medication reconciliation varies greatly. Medication discrepancies range from 41 to 98% in the literature with large proportions of these discrepancies considered potentially high risk for causing adverse drug events.[3,6] Low health literacy, the large number of possible medications, complexity of medication names, doses and frequencies, and difficulties in communicating such as English language proficiency all affect accuracy of medication reconciliation.[7-9] Older patients are a particularly at risk with medication discrepancies as high as 82% reported in this population.[10-13]

The trauma setting makes medication reconciliation more important and more complicated because of the urgency of decision-making and the massive demographic changes currently underway. Trauma is the leading cause of death in the United States for patients under 44 y of age with over 37 million trauma visits per year and annual costs over $600 billion (2013).[14] Trauma patients present with unique problems that limit medication reconciliation, such as severe or distracting injuries, loss of consciousness, intoxication, anxiety associated with traumatic events, and the urgent nature of emergency care, compared with other, medical, patients who may be more able participate in their care. Geriatric trauma volumes are increasing in particular, in absolute numbers as well as in proportion to all trauma admissions.[15] An estimated 90% of older adults are on some kind of prescription medication and 39% are on more than five medications which makes trauma care more difficult.[11]

Therefore, we need effective strategies to perform medication reconciliation in trauma. But there has been sparse research on this topic.[16] We have shown in a recent systematic review that there have only been four papers on medication reconciliation in trauma and their accuracy rates were abysmal.[16] In this article, we review existing medication reconciliation strategies, evaluate their applicability to the trauma patient population and discuss accurate medication reconciliation in high-risk subpopulations.

Existing medication reconciliation strategies and their applicability in trauma

Performing an accurate medication reconciliation is often difficult, time-consuming, and costly.[1,17,18] The medical literature reports many strategies such as using pharmacists or pharmacy technicians, modifying the electronic medical record, and designing patient-centered techniques to facilitate safe patient care. However, it is unclear if any of these strategies could be effectively applied to address medication reconciliation in trauma patients.

Pharmacists

Pharmacist-based interventions are among the best studied in the literature. Pharmacists have effectively worked with diverse patient populations such as nursing home residents, elderly patients, and patients with HIV, COPD, and heart failure in performing medication reconciliation.[19-23] Several systematic reviews and meta-analyses have compiled existing data on pharmacist-led interventions and have shown reductions in medication discrepancies, hospital and emergency visits and readmissions, although none have shown effect on mortality. The most recent and highest quality study focused on only randomized controlled trials and found that pharmacists reduced medication discrepancies with a pooled risk ratio of 42% across 18 studies and over 6000 participants ($P < 0.00001$), but had no significant effect on potential and preventable adverse drug events or in health care use.[24] Another systematic review and meta-analysis also of randomized controlled trials of in-hospital pharmacist-led medication reviews found no effect on a composite outcome of all-cause readmission and/or emergency department (ED) visit rates or on all-cause mortality and length of stay based on 19 randomized control trials and 4805 participants. Drug-related readmissions and all-cause ED visits as individual secondary outcomes, however, were reduced in the pharmacist intervention group (RR = 0.25, $P < 0.001$ and RR = 0.70, $P = 0.001$, respectively).[25] Pharmacist-led medication reconciliation at care transitions with comprehensive medication reconciliation programs (i.e., telephone or home follow-up, patient counseling, medication review, etc.) were assessed in a heterogeneous analysis of 17 studies and over 21,000 participants. This study showed a 67% risk reduction for ADE-related hospital revisits ($P < 0.00001$), 28% for all-cause ED visits ($P = 0.008$) and 19% for all-cause hospital readmissions (P value = 0.009), without any difference in mortality.[26] These suggest that pharmacist-based medication reconciliation has

potential to reduce errors, complications, and readmissions even if no direct mortality benefit is found. These benefits in themselves can be valuable for trauma patients because this population tends to be at high risk of such events due to complexity and need for multiple care transitions and care teams.

However, there are several challenges to implementing pharmacist-based medication reconciliation at busy trauma centers. Hiring enough pharmacists to either obtain medication reconciliations or to oversee and monitor pharmacy technicians to obtain them may be expensive. Nguyen *et al.* estimated the cost of completing admission medication reconciliation at $55.91 per patient for pharmacists and $45.00 per patient for technicians, respectively.[17] At our busy tertiary care center, which has over 4000 trauma admissions, this strategy would cost $180,000-$224,000 annually or $1.71 million to 2.12 million annually for approximately 38,000 yearly hospital admissions from the ED.[27] Therefore, the practical implementation may be limited.

Furthermore, even with expert pharmacy staff, medication reconciliation remains time-consuming and therefore may not be practical in trauma.[17,28] Miller *et al.* found that pharmacists took 3 d on average after trauma (range 1-8 d) to complete the medication reconciliation, with a median of 2 d.[8] This hardly allows for informed decision-making early in trauma care. In an evaluation of 11,000 alert and cooperative medical patients, pharmacy technicians were able to provide a complete medication reconciliation in an average of 23 min although this was only completed before admission order entry in 21%.[28] Again, the process itself may be limited despite adequate staffing. Therefore, in the high-acuity trauma setting, pharmacist-based medication reconciliation may be costly and time-consuming. Finally, even if these challenges were surpassed, pharmacists would still only be able to determine the medications prescribed, but not necessarily the more useful information necessary for rapid decision-making in trauma of what was actually taken by the patient before hospital arrival.

Electronic medical record tools

Electronic medical record (EMR) tools have been shown to improve the medication reconciliation process by identifying errors, reducing drug omission errors, highlighting the medications that differ between a home and discharge medication list, automatically grouping medications by therapeutic class, and identifying duplicates.[29] A comparison of two versions of an EMR medication reconciliation tool found that the system that displayed drugs in a side-by-side view (i.e., home medications compared with hospital medications), automatically grouped medications by therapeutic class and effectively identified duplicates reduced the total number of drug errors significantly ($P < 0.0001$).[29] Another EMR tool compared the home medication list with the post hospital discharge medication list and then proceeded to highlight the changes or differences which helped update the home medication list accordingly.[30] Other EMRs have been designed with a hard stop to perform medication reconciliation on admission and ensure that this critical process is performed.[31] These have shown encouraging results; however, their applicability in trauma may be limited for a variety of reasons.

EMR customization is likely to be expensive and logistically challenging based on the variety of different EMRs that hospitals use. EMRs are not interoperable across hospital systems, which limits access to medication data from other facilities. Having medication reconciliation as a hard stop would interfere with the emergent care of trauma patients. Furthermore, EMR tools still do not address the unique challenges of medication reconciliation in this patient population including altered level of consciousness, low health literacy, and lack of knowledge of medications particularly in the elderly. Even if a single EMR vendor had the majority share of the market and allowed medication information to be shared across institutions and facilities, what the patient actually took before arriving at the hospital would still be unanswered. Thus, while EMR-based interventions may be effective for nonacute medical care, they are likely to have limited utility for the trauma setting.

Patient-centered medication reconciliation

Active patient participation or patient-centered medication reconciliation has been successful in the Veterans Affairs "Secure Messaging for Medication Reconciliation Tool" study in which 60 recently discharged patients verified their medications or clarified discrepancies in their medications by reviewing of their medication lists and using secure email exchange to communicate with their treating teams. Although this study had a small sample size, using this process, it still found 108 medication discrepancies and 23 adverse drug events, with approximately 50% of the adverse drug events classified as serious emphasizing the need for accurate medication reconciliation.[32] Another pilot study evaluated artificial intelligence–enabled support tools in the patient-centered medication reconciliation process. This study asked patients to confirm their medication history before being seen for a clinic visit on a tablet. The medication reconciliation was then reviewed with the nurse, physician, and the patient simultaneously. Ten patients used specific software to correct their medication profiles and each found at least one error or issue with their medication list in the EMR.[33]

Such patient-centered tools are increasingly available in health care and represent a promising approach, although again may not be practical for the acutely injured patient who is incoherent or incapacitated or may have trouble navigating the urgent nature of care due to low health literacy, polypharmacy, complex medication names, doses and frequencies, or older age.[7-9,34] Therefore, these tools may not offer a one-size-fits-all approach to the diverse trauma patient population.

High-risk populations

Children, the elderly, and brain-injured patients are special populations that are particularly vulnerable to medical errors from poor medication reconciliation. Reported strategies for medication reconciliation in these populations may offer important lessons.

Pediatrics

There are few studies on medication reconciliation in children. A systematic review of 10 studies related to medication

Table 1 – Studies reviewed in this paper on medication reconciliation strategies and special populations.

Author, year	Methodology	Intervention	Findings
Cheema *et al.*, 2018	Systematic review/meta-analysis of 18 RCTs, 6000 participants	Pharmacist-based medication reconciliation	Reduced medication discrepancies—pooled risk ratio of 42% ($P < 0.00001$). No effect on potential and preventable adverse drug events or in health care use.
Renaudin *et al.*, 2016	Systematic review/meta-analysis of 19 RCTs, 4805 participants	In-hospital pharmacist-led medication reviews	Drug-related readmissions and all-cause ED visits reduced (RR = 0.25, $P < 0.001$ and RR = 0.70, $P = 0.001$).
Mekonnen *et al.*, 2016	Heterogeneous analysis of 17 studies and over 21,000 participants	Pharmacist-led medication reconciliation at care transitions	67% risk reduction for ADE-related hospital revisits ($P < 0.00001$), 28% for all-cause emergency department visits ($P = 0.008$), 19% for all-cause hospital readmissions (*P* value = 0.009), No difference in mortality.
Horsky *et al.*, 2017	Prospective cohort comparison of two different EMRs, 17 clinicians	EMR based	One EMR reduced the mean number of drug errors significantly compared with the other ($P < 0.0001$).
Schnipper *et al.*, 2011	Intervention implementation, 103 PCPs, 10 practices	EMR based	No statistical comparison, solely lessons learned from implementation.
Rizzato Lede *et al.*, 2015	Cross-sectional, descriptive study of EMR implementation, 27,375 patients	EMR based	No statistical comparison, solely lessons learned from implementation.
Heyworth *et al.*, 2014	Intervention implementation, 60 patients	Patient-centered	108 medication discrepancies and 23 adverse drug events, with approximately 50% of the adverse drug events classified as serious.
Long *et al.*, 2016	Cross-sectional; AI based; 10 patients	Patient-centered	Each found at least 1 + error with their medication list in the EMR.
Huynh *et al.*, 2013	Systematic review; children at care transitions; 10 studies	Medication reconciliation interventions in pediatric settings	Rate of medication discrepancy varied from 22 to 72.3%.
Gardner *et al.*, 2009	Prospective cohort, intervention; children	Pharmacist-led medication reconciliation	Changes made in 85% of medication reconciliations.
Terry *et al.*, 2010	Prospective observational, pediatric neurosurgical patients	Pharmacist-led medication reconciliation	Initial admission medication orders differed from prescribed preadmission medication in 39% - half had potential for moderate-severe discomfort or clinical deterioration.
Franco *et al.*, 2017	Cross-sectional comparison of electronic medical record (EMR) medication lists and patient's self-report, 150 elderly	Patient-centered	99% had 1 + discrepancy, 1252 discrepancies; 46% taking undocumented medication; 93% not taking a prescribed medication.
Chiu *et al.*, 2018	Prospective cohort, 212 elderly	Pharmacist-led medication reconciliation	Fewer patients had inappropriate medications at discharge (28.0% *versus* 56.4%; $P < 0.001$), lower unplanned hospital readmission rate 1 mo after discharge (13.2% *versus* 29.1%; $P = 0.005$), no difference in length of hospital stay, number of emergency department visits, or mortality.
Renaudin *et al.*, 2017-present	RCT, 1400 patients	Pharmacist-led medication reconciliation *versus* usual care	In progress.
Nishijima *et al.*, 2017	Retrospective, 2110 TBI patients ≥ 55 y	Standard process, anticoagulant and antiplatelet agents	28% *versus* 16.5% accuracy for hospital *versus* prehospital staff.

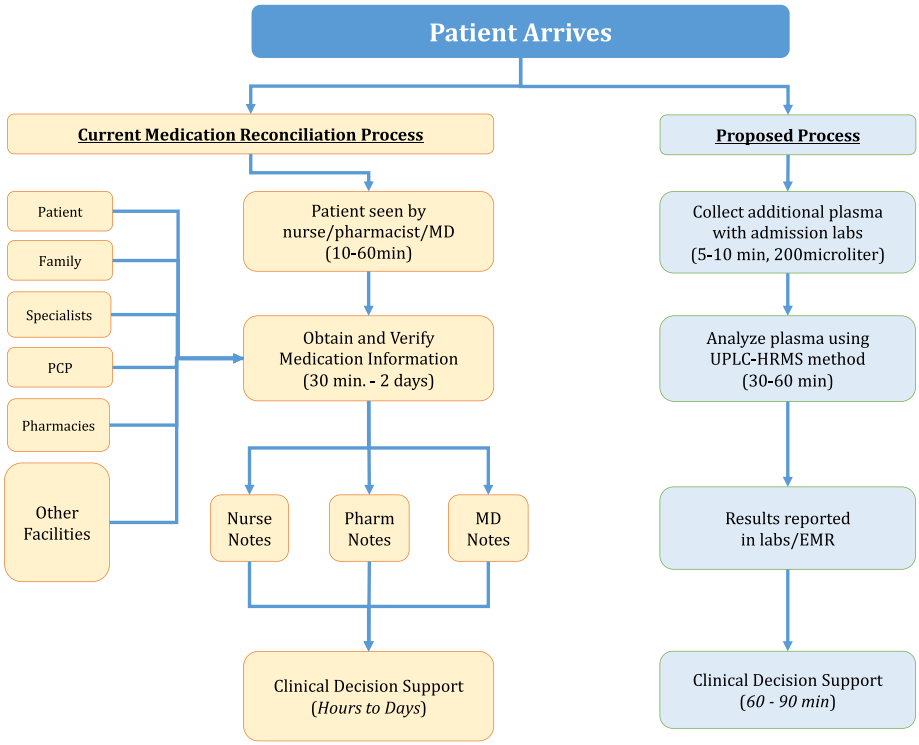

Fig. 1 – Current *versus* proposed approaches to medication reconciliation. The current medication reconciliation process column represents the existing standard of care. The proposed column represents medication reconciliation performed using novel mass spectrometry–based diagnostic assay. (Color version of figure is available online.)

discrepancies in pediatric patients at transitions of care found that the rate of medication discrepancy varied from 22 to 72.3%.[35] When pediatric pharmacists performed admission and transfer patients' medication reconciliations in a 15-month-long study, they had to make changes in 85% of cases.[36] Regardless, medication reconciliation has not been recognized as an important issue in pediatric trauma. Only one pediatric trauma-specific medication reconciliation study

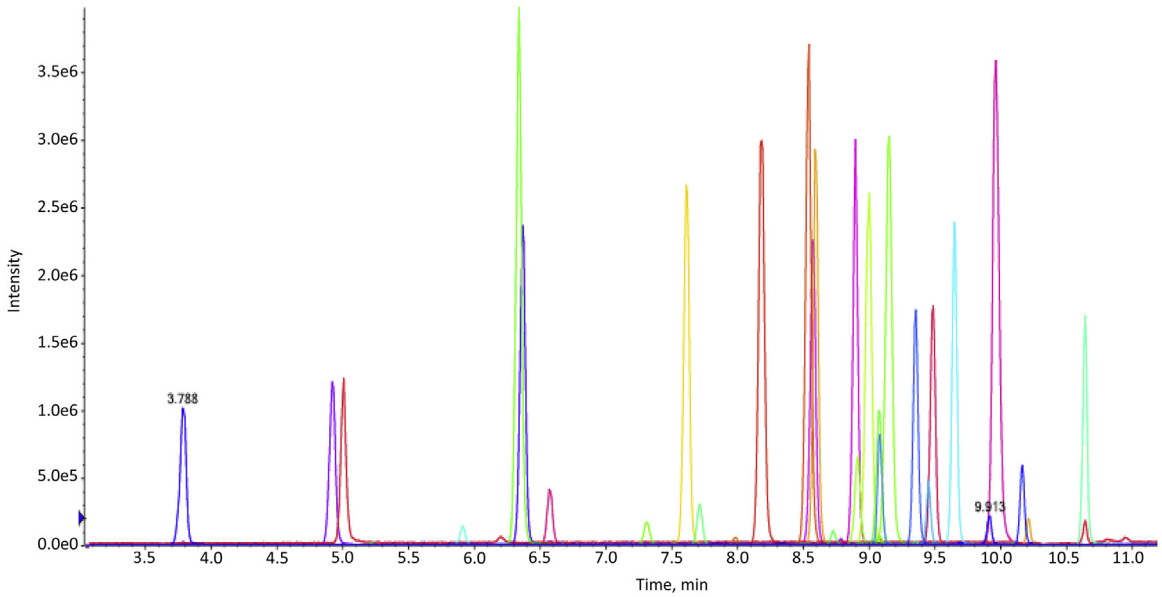

Fig. 2 – UPLC HRMS provides sufficient sensitivity and specificity to accurately identify prescription medications from plasma. Medications analyzed were atenolol, metoprolol, clonidine, digoxin, carbamazepine, amitriptyline, apixaban, dabigatran, warfarin, olanzapine, risperidone, quetiapine, phenytoin, verapamil, propranolol, diltiazem, pioglitazone, triamterene, nifedipine, amlodipine, clopidogrel, sitagliptin, irbesartan, valsartan, losartan, glipizide, and glyburide. (Color version of figure is available online.)

was found by the authors in a PubMed search and this reported 39% discrepancy at admission to a hospital in the UK.[37] Accurate medication reconciliation remains an important safety factor for injured children.

Older adults

Older adults are at particular risk for medical errors and poor outcomes. They tend to have multiple comorbidities, be prescribed multiple medications, especially anticoagulants, and be poor historians.[34,38] Their medication use can be difficult to discern. In one study of 150 outpatients over 65, the mean number of medications reported by each person was nine, whereas the mean number prescribed based on their EMR record was 14. The study also found at least one discrepancy in 99% of cases for a total of 1252 discrepancies. Nearly half (46%) of the patients had taken at least one prescription not documented in their EMR and 93% did not take at least one of the prescribed medications listed in their EMR.[39] Clearly, medication reconciliation in the older adult population is a challenge.

Pharmacist-based medication reconciliation has been studied closely in the older adult population. One prospective cohort study compared pharmacist-led medication reconciliation, medication review, and medication counseling with usual care in 212 patients over 65 y and found that fewer patients had inappropriate medications at discharge in the intervention group (28.0% *versus* 56.4%; $P < 0.001$). The unplanned hospital readmission rate 1 mo after discharge was also significantly lower in the intervention group (13.2% *versus* 29.1%; $P = 0.005$) but there were no differences in the length of hospital stay, number of ED visits, or mortality rate.[40] A large, randomized control trial of 1400 patients is in progress in France to evaluate the extremes of age in standard compared with pharmacist-led medication reconciliation.[20] These limited studies suggest potential benefits of pharmacy-led medication reconciliation for the older trauma patient population; however, many of the limitations on this approach discussed previously will continue to apply.

Traumatic brain injury

Patients with traumatic brain injury (TBI), especially those who are on anticoagulants and antiplatelet medications before injury, represent another major group at high risk for poor, and potentially even fatal, outcomes. Age 75 y or older has been shown to be an independent risk factor for predicting coagulopathy after TBI.[41,42] These concerns have only increased because direct-acting oral anticoagulants (DOACs) have entered the market.[43] There are no routinely available methods that accurately detect their presence or therapeutic level thus DOACs represent a major challenge in the management of elderly patients with TBI.[44] However, there have been few papers published specifically studying medication reconciliation in patients with TBI. One retrospective analysis of 2110 TBI patients aged 55 y or older showed that hospital staff and prehospital staff were abysmal (28% and 16.5%, respectively) at determining preinjury use of anticoagulants and antiplatelet medications.[45] Clearly, better methods of accurate medication reconciliation in this patient group are needed to prevent potentially devastating outcomes.

All reported medication reconciliation strategies are likely to have severe limitations in the trauma setting (Table 1). Furthermore, time and cost remain major challenges. For example, when a pharmacist completes the process, admission medication reconciliation can take an average of 58.4 min in a cooperative patient and cost a minimum of $55.91 per patient.[17] There are no data on the resources needed to perform medication reconciliation in incoherent or incapacitated trauma patients or on the impact of inaccurate medication reconciliation on clinical outcomes in trauma. These need to be studied more specifically based on the massive burden of trauma in the United States.[14]

Our multidisciplinary group has been studying medication usage in geriatric trauma and have been working on developing a novel diagnostic assay using high resolution liquid chromatography and mass spectrometry to rapidly detect critical medications in plasma (Fig. 1). This technology has been widely used in agriculture to detect known and unknown chemicals.[46,47] As such, the applicability to medication detection is novel but a natural extension of existing processes. Standard coagulation assays do not accurately detect DOACs.[44,48] Some groups have started to assess the value of this technology to detect DOACs in human plasma and even in orthopedic surgery patients.[49-53] But, there has been no reported work in trauma patients. We envision an objective, clinically validated assay that is reproducible and accurate and can performed alongside standard admission STAT labs with similar turnaround time. We have developed this method to detect DOACs in elderly trauma patients and have found very high accuracy rates; the results are under review.[54]

This method may also be useful in other surgical fields, such as transplant, cardiac, vascular, and pediatric surgery, because patients in those fields may be unable to communicate or may be on critical medications whose presence or absence in blood will have substantial impact on clinical care. Our group is in the process of testing several hundred samples from the clinical setting and developing assay panels of critical medications specific to trauma, myocardial infarction, stroke, and sepsis to allow rapid, accurate, and reproducible methods of detecting medications in these high-risk conditions. Figure 2 demonstrates our analysis of 30 common prescription medications that were spiked into drug free plasma and evaluated using our assay, which serves as a proof of concept. Although this may not be the only strategy to address medication reconciliation, we anticipate that such objective methods may help determine this information in a standardized, accurate, and reproducible manner in high-risk patients, in critical settings and during care transitions, and contribute to safer medical care.

Conclusion

Trauma patients are at high risk for complications due to errors in medication reconciliation. Current strategies have poor accuracy, tend to be costly and time-consuming and therefore are poorly applicable to the trauma patient population. Further research is needed to create a safe and efficient system for medication reconciliation in trauma patients.

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