Impact of the addition of clinical pharmacy services to the cardiac catheterization laboratory

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Purpose: Our cardiology pharmacy team recently expanded services to the cardiac catheterization laboratory (CCL) with the addition of a dedicated pharmacist; since that time, numerous process improvement initiatives have been implemented and medication review has been expanded.

Methods: We conducted a single-center retrospective chart review. The primary outcome was the percentage of patients discharged from the CCL on appropriate guideline-directed medical therapy components after percutaneous coronary intervention (PCI) before and after integration of dedicated pharmacist services in the CCL. Secondary outcomes were assessed for all patients discharged from the CCL after implementation of a pharmacy presence and included the total number of pharmacist interventions at discharge, the number of prescriptions directed to our outpatient pharmacy, the number of medication reconciliations performed, the number of "protect your stent" educational sessions completed, and the number of clinically significant pharmacist interventions to the medication regimens of patients who underwent PCI.

Results: After a dedicated pharmacist was integrated to review CCL discharges, significantly more patients were discharged on high-intensity statin therapy (47.9% vs 78.0%; $P < 0.0001$) and fewer patients were discharged on omeprazole or esomeprazole prescribed concurrently with clopidogrel (18.7% vs 3.9%; $P < 0.0001$) following PCI. Of the patients who underwent PCI after addition of the pharmacist (n = 259), 23.9% (n = 66) had a clinically significant pharmacist intervention at discharge and 96.5% (n = 250) received protect your stent education. Of all discharges following pharmacist integration (n = 3,501), 13.6% (n = 477) had at least one pharmacist intervention, 771 prescriptions were sent to our outpatient pharmacy, and 66.4% (n = 2,325) of patients had a medication reconciliation completed.

Conclusion: Addition of a dedicated pharmacist to the CCL was associated with increased rates of high-intensity statin prescribing and decreased use of esomeprazole and omeprazole with clopidogrel.

Keywords: cardiac catheterization, coronary artery disease, percutaneous coronary intervention, pharmacists

Am J Health-Syst Pharm. 2025;82:e358-e364

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https://doi.org/10.1093/ajhp/zxae215

Percutaneous coronary intervention (PCI) is a procedure commonly performed for patients with obstructive coronary artery disease if they have symptoms associated with chronic coronary disease or an acute coronary syndrome (ACS) event.[1] Patients who have undergone PCI with placement of a drug-eluting or bare metal stent are at high risk of adverse events, including stent thrombosis and bleeding, in the months following their procedure. Current guidelines recommend that patients undergoing PCI should typically be prescribed dual-antiplatelet therapy (DAPT) with aspirin 81 mg daily plus clopidogrel 75 mg daily, prasugrel 5 to 10 mg daily, or ticagrelor 90 mg twice daily for a minimum of 6 to 12 months, followed by monotherapy with aspirin

81 mg for life. Certain patients may be candidates for a shorter or longer DAPT duration depending on their characteristics and their indication for PCI.[1] Additionally, patients chronically taking anticoagulation for a thromboembolic condition typically receive a short course of DAPT plus anticoagulation followed by single-antiplatelet therapy plus anticoagulation, which may be further de-escalated to anticoagulation monotherapy.[2] The appropriate antiplatelet regimen following PCI is critical to prevent stent thrombosis and mitigate bleeding risk.[1,2]

Patients who undergo PCI may also be candidates for therapy with a high-intensity statin, angiotensin-converting enzyme inhibitor (ACEI) or angiotensin receptor blocker (ARB), and β-blocker to complete their guideline-directed medical therapy (GDMT) regimen based on their comorbidities and preferences.[3,4] Pharmacists have a unique skill set that allows them to identify inappropriate or missing GDMT before discharge following PCI and make interventions to ensure patients are on optimized medical therapy. However, pharmacists are not routinely staffed exclusively in the cardiac catheterization laboratory (CCL).

Before January 2020, patients who underwent PCI at our institution were typically admitted to the floor, where an internal medicine or cardiology pharmacist reviewed their orders before discharge. This pharmacist was able and encouraged to intervene on discharge orders and make recommendations to add missing therapies, modify inappropriate medications, and ensure patients had access to their medications immediately after discharge. If patients were discharged directly from the procedural area without staying overnight, a pharmacist did not review their discharge orders.

In January 2020, our CCL was renovated to allow certain patients to stay overnight and be discharged directly from the CCL; however, there was still no review of patients' discharge orders by a pharmacist unless they stayed overnight. When an internal review was performed of patient safety data, the cardiology pharmacist team noticed concerning trends in patients' discharge medication regimens and began advocating for a pharmacist dedicated to staff the CCL. In November 2020, a cardiology pharmacist (1.0 full-time equivalents funded from the pharmacy department) was designated to exclusively staff the CCL and began reviewing all discharge orders for patients discharged directly from the CCL regardless of whether patients stayed overnight. As previously, the CCL pharmacist has a responsibility to intervene on discharge orders and make recommendations to providers to optimize therapy. Numerous other process improvement initiatives have been implemented with the addition of a pharmacist to the CCL team. In the literature, limited data are available describing the potential benefits of a pharmacy presence in this novel clinical practice site.

KEY POINTS

- The cardiac catheterization laboratory is a novel site for pharmacists to practice, and there are no published data regarding the benefits of pharmacist presence in this area.
- Pharmacist presence led to higher rates of appropriate guideline-directed medical therapy prescribing following percutaneous coronary intervention.
- Pharmacy presence was associated with many other quality improvement measures, including patient education, medication reconciliation, and utilization of the onsite pharmacy.

Methods

We conducted a retrospective, single-center chart review. Data were collected for patients in 2 time periods: July 2018 through June 2019 (preimplementation period) and July 2021 through June 2022 (postimplementation period). These time periods were chosen to capture the years before and after implementation of a pharmacy presence with as little interference as possible from coronavirus disease 2019 (COVID-19). The primary outcome was measured in all patients who underwent PCI and were discharged from observation status in the 2018-2019 cohort or underwent PCI and were discharged directly from the CCL in the 2021-2022 cohort. Only patients discharged from observation status were included in the 2018-2019 cohort to mimic the population of primarily patients with chronic coronary disease that would likely have been discharged directly from the CCL had this been an available option. Patients who undergo PCI for ACS are admitted to an inpatient service and are not discharged from observation status or the CCL. Secondary outcomes were measured on all patients who underwent a procedure in and were discharged directly from the CCL in the postimplementation period. Only patients from the postimplementation period were included in secondary outcomes as the measured initiatives were not present before presence of a pharmacist in the CCL and we sought to quantify rather than compare these initiatives. Note that secondary outcome data were included for patients who underwent any procedure in the CCL, whereas the primary outcome was assessed only in patients who underwent PCI.

The primary endpoint of this study was the percentage of patients who were on each component of appropriate GDMT at discharge after undergoing PCI in the time periods before and after addition of a pharmacist who reviewed discharge orders from the CCL. Components of appropriate GDMT measured included aspirin 81 mg daily, an oral $P2Y_{12}$ inhibitor (clopidogrel, prasugrel, or ticagrelor), omeprazole or esomeprazole not prescribed concurrently with clopidogrel

(as the manufacturer's labeling recommends avoiding concurrent use of these medications), high-intensity statins, an ACEI or ARB, and a β-blocker.[1,3-6] The appropriateness of the DAPT regimen was not assessed, including in patients who were on anticoagulation concurrently with antiplatelet therapy. These patients were included in the analysis, but the presence of DAPT at discharge was quantified in the same way that it was for patients who were not on anticoagulation. Additionally, high-intensity statin therapy included only atorvastatin 40 or 80 mg daily and rosuvastatin 20 or 40 mg daily, and the appropriateness of the statin dose and nonstatin therapies intervened on was not assessed.[3]

Secondary endpoints measured in patients who underwent PCI in the postimplementation period included the number of clinically significant pharmacist interventions at discharge and the number of "protect your stent" educational sessions provided. Clinically significant interventions were only quantified for patients who underwent PCI as part of the primary outcome, and only patients who undergo PCI receive protect your stent education; because of this, these secondary endpoints were measured only in patients who underwent PCI. Secondary endpoints measured for all discharges in the postimplementation period included the percentage of total discharges that had at least one pharmacist intervention, the number of prescriptions directed to our outpatient pharmacy, and the number of medication reconciliations performed.

The objective of this study was to quantify pharmacist interventions for GDMT after PCI. Therefore, the interventions defined as clinically significant for our purposes were adding a $P2Y_{12}$ inhibitor or aspirin if omitted or optimizing any DAPT regimen (such as by changing clopidogrel to a more potent $P2Y_{12}$ inhibitor if indicated or de-escalating a more potent $P2Y_{12}$ inhibitor to clopidogrel if appropriate), adding or increasing the dose of a statin for high-intensity therapy, adding a β-blocker if indicated, adding ACEI or ARB therapy if indicated, changing or discontinuing omeprazole or esomeprazole when used with clopidogrel, and any intervention that prevented a delay in a patient immediately starting therapy at discharge. While data were not collected on the $P2Y_{12}$ inhibitor chosen, interventions on omeprazole or esomeprazole were only counted if clopidogrel was the $P2Y_{12}$ inhibitor prescribed. Although the clinical significance of this drug interaction is under debate, the Food and Drug Administration continues to recommend avoiding this combination of therapies.[5,6] For this reason, we considered an intervention to address concurrent prescribing a clinically significant intervention. Interventions that prevented a delay in medication attainment were counted as clinically significant if the pharmacist sent the prescriptions to any in-person pharmacy rather than a mail-order pharmacy or to a pharmacy that was open if the patient's preferred pharmacy was closed at the time of discharge.

Baseline characteristics were analyzed using descriptive statistics. Data for the primary outcome were analyzed using a χ^2 test with a significant P value of ≤0.05. This research was considered exempt by our internal institutional review board. Written informed consent was not required for participation in this study.

Results

A total of 543 patients were included for the primary outcome, consisting of 284 patients who underwent PCI from 2018 through 2019 and 259 patients who underwent PCI from 2021 through 2022. Baseline characteristics were well balanced between the groups apart from a higher rate of high-intensity statin therapy at baseline in the postimplementation period (Table 1). Nearly all patients included for the primary outcome were admitted for elective PCI, including 98.6% of patients in the preimplementation

Table 1. Baseline Characteristics of Patients Included for the Primary Outcome

Characteristic[a]	Preimplementation period (n = 284)	Postimplementation period (n = 259)
Age, mean (SD), years	67.2 (10.2)	67.6 (10.8)
Male gender	208 (73.2)	181 (69.9)
Elective PCI	280 (98.6)	259 (100)
$P2Y_{12}$ inhibitor	116 (40.8)	116 (44.8)
Aspirin	244 (85.9)	212 (81.9)
Omeprazole or esomeprazole	59 (20.8)	48 (18.5)
High-intensity statin	110 (38.7)	146 (56.4)
ACEI or ARB	151 (53.2)	143 (55.2)
β-blocker	192 (67.6)	178 (68.7)

Abbreviations: ACEI, angiotensin-converting enzyme inhibitor; ARB, angiotensin receptor blocker; PCI, percutaneous coronary intervention.
[a]Data shown as No. (%) unless indicated otherwise.

Table 2. Discharge Medication Regimens for the Primary Outcome

Medication[a]	Preimplementation period (n = 284)	Postimplementation period (n = 259)	*P* value
$P2Y_{12}$ inhibitor	282 (99.3)	257 (99.2)	0.93
Aspirin	262 (92.2)	249 (96.1)	0.055
Omeprazole or esomeprazole	53 (18.7)	10 (3.9)	<0.00001
High-intensity statin	136 (47.9)	202 (78.0)	<0.0001
ACEI or ARB	160 (56.3)	148 (57.1)	0.85
β-blocker	202 (71.1)	186 (71.8)	0.86

Abbreviations: ACEI, angiotensin-converting enzyme inhibitor; ARB, angiotensin receptor blocker.
[a]Data shown as No. (%).

period and 100% of patients in the postimplementation period. A total of 3,501 patients were included for the secondary outcomes, of whom 259 underwent PCI.

Results for the primary outcome are shown in Table 2. Rates of $P2Y_{12}$ inhibitor, aspirin, ACEI or ARB, and β-blocker therapies did not differ significantly between the pre- and postimplementation groups. Significantly more patients were discharged on high-intensity statin therapy in the postimplementation group (47.9% vs 78.0%; $P < 0.0001$). Additionally, significantly fewer patients were discharged on omeprazole or esomeprazole (18.7% vs 3.9%; $P < 0.0001$).

Overall, 23.9% of patients (66 patients) in the postimplementation period had a clinically significant pharmacist intervention at discharge following PCI. The most common intervention was changing from omeprazole or esomeprazole when clopidogrel was the selected $P2Y_{12}$ inhibitor, which made up 36.4% of all clinically significant interventions. Adding or increasing the dose of a statin to high-intensity therapy was the next most common intervention, making up 24.2% of all clinically significant interventions. Intervening on missing or inappropriate DAPT, adding angiotensin-blocking therapy, and preventing delays in obtaining prescriptions made up 19.7%, 7.5%, and 12.1% of clinically significant interventions, respectively (Table 3).

Table 3. Secondary Outcomes Assessed for Patients in the Postimplementation Period Undergoing PCI

Outcome[a]	Patients (n = 259)
Clinically significant interventions	66 (23.9)
DAPT	13 (19.7)
PPI	24 (36.4)
Statin	16 (24.2)
β-blocker	0 (0)
ACEI or ARB	5 (7.5)
Delay prevented	8 (12.1)
"Protect your stent" education	250 (96.5)

Abbreviations: ACEI, angiotensin-converting enzyme inhibitor; ARB, angiotensin receptor blocker; DAPT, dual-antiplatelet therapy; PPI, proton pump inhibitor; PCI, percutaneous coronary intervention.
[a]Data shown as No. (%) except for clinically significant interventions overall, which are shown as No. (% of patients with at least one).

Table 4. Secondary Outcomes Assessed for All Patients in Postimplementation Period

Outcome	Discharges (n = 3,501)
At least 1 intervention at discharge, No. (%)	477 (13.6)
Prescriptions sent to onsite outpatient pharmacy, No.	771
Medication reconciliation completed, No. (%)	2,325 (66.4)

Results for other secondary outcomes are shown in Table 3 and Table 4. Of the 259 patients who underwent PCI, 96.5% received protect your stent education. Of the 3,501 total discharges, 13.9% had at least one pharmacist intervention, 66.4% had a medication reconciliation completed before discharge, and 771 prescriptions were sent to the outpatient pharmacy associated with our institution.

Discussion

This retrospective chart review included 284 patients who underwent PCI and were discharged from observation status between July 1, 2018, and June 30, 2019, and 3,501 patients

discharged directly from our CCL between July 1, 2021, and June 30, 2022. After a dedicated pharmacist was added to review discharges in the CCL, significantly more patients were discharged on high-intensity statin therapy and without clopidogrel plus omeprazole or esomeprazole following PCI. Together, these 2 components of GDMT corresponded to the most common areas for pharmacist intervention at discharge, indicating a positive relationship between pharmacist interventions and improved rates of GDMT prescribing. This highlights the importance of pharmacist review of discharge medication regimens and the ability of pharmacists to provide recommendations to optimize these regimens.

The high rate (>99%) of elective PCI among patients included for the primary outcome was expected, as patients who require emergent PCI for ACS are not frequently discharged from observation status or the CCL directly. Because nearly all patients included for the primary outcome of this study underwent elective PCI, the recommendations for GDMT differ slightly when compared to those for patients who undergo emergent PCI. Clopidogrel is the $P2Y_{12}$ inhibitor of choice for patients who undergo elective PCI unless the patient has a compelling indication for a more potent inhibitor, such as a recent ACS event.[1,6] High-intensity statin therapy is recommended for most patients with coronary artery disease, but ACEI or ARB and β-blocker therapy may not be appropriate in all patients who undergo elective PCI.[3,4] This could explain the high rates of pharmacist intervention on high-intensity statin therapy and concurrent prescribing of esomeprazole or omeprazole with clopidogrel but not on ACEI or ARB and β-blocker therapies.

Pharmacy presence was also associated with high rates of patient education and medication reconciliation, as well as interventions on all discharges and the ability to send prescriptions directly to the patient's bedside through our institution's outpatient pharmacy. New prescriptions can be sent to any pharmacy of the patient's choosing; however, if they normally fill through mail order or their chosen pharmacy is closed, it is highly encouraged to fill their prescriptions at our onsite pharmacy to ensure they have possession of their medications before discharge. The "meds-to-beds" program at our onsite pharmacy, in which medications are delivered to the bedside before discharge, is frequently utilized in these cases. If prescriptions are sent anywhere that is not the patient's normal pharmacy, patients are educated to proactively transfer any refills to a pharmacy of their choosing well before they run out of medication. Although sending prescriptions to a pharmacy where a patient has not filled before has its limitations, the CCL pharmacist meticulously screens each patient's discharge regimen to avoid drug or disease interactions that would typically be recognized by a patient's retail pharmacist. Through sending prescriptions to in-person pharmacies that were open for business at the time of the patient's discharge, the CCL pharmacist addressed potential delays in starting therapy associated with mail order or a closed pharmacy, which is critical to prevent adverse stent outcomes. We were unable to quantify the financial benefit of sending medications to our onsite pharmacy or the total number of prescriptions sent to our pharmacy by our institution for the purposes of this study.

Aside from performing a clinical review, the CCL pharmacist is also able to assess logistical barriers to medication therapy on discharge. Before addition of pharmacist staffing in the CCL, most of these patients did not have their discharge reviewed by a pharmacist and we therefore did not have programs set up through our outpatient pharmacy for this area, including our meds-to-beds program. Once a clinical pharmacist was staffing this area, meds-to-beds services were expanded to the CCL. This also expanded access to our medication access coordinators who are specially trained pharmacy technicians that assist patients who have trouble affording their medications. By addressing these logistical barriers, the CCL pharmacist plays an integral role in ensuring patients have access to their medications at discharge.

The selected secondary outcomes were chosen to quantify quality improvement initiatives that have been implemented by the CCL pharmacist. Pharmacists can make a variety of interventions on any CCL discharge, and we sought to quantify these to account for the work pharmacists do to optimize medication regimens at discharge. The ability for the CCL pharmacist to send prescriptions to our outpatient pharmacy rather than an offsite pharmacy indirectly correlates with a potential for increased revenue for our hospital and an enhanced ability to ensure patients have access to their medications before discharge. Protect your stent education is given specifically to patients undergoing PCI to enhance their understanding of the purpose of cardiac stents and the medications they have been prescribed to reduce the risk of complications. This education emphasizes the importance of adherence and encourages patients to continue taking their medications unless directed otherwise by a prescriber. This education was created by the CCL pharmacist, and, while it was initially performed only on patients discharged from the CCL, it has since been expanded to be provided to patients discharged from anywhere across the institution. Admission medication reconciliations are performed on all patients admitted to our institution but were not previously performed for patients who were discharged directly from the CCL. By expanding pharmacist services to this area, we were able to complete admission medication reconciliations for the majority of patients in the CCL.

Although not quantified in this study, several other quality improvement initiatives have been integrated into the CCL workflow since the addition of a pharmacist. These included implementation of a perioperative antibiotic substitution policy that allows

the pharmacist to optimize antibiotic selection in the CCL, encouraging optimization of antimicrobial selection and avoidance of inappropriate escalation of therapy. Other initiatives included creation of an intracoronary dosing guidance document for medications in left heart catheterization, development of a heparin dosing nomogram for use during PCI, formal education for all members of the healthcare team on a variety of medication-related topics, creation of a cangrelor protocol with decision support, development of a discharge flag in the electronic health record to alert prescribers when DAPT has not been prescribed after PCI, optimization of an eptifibatide workflow in the CCL, implementation of a checklist to ensure proper anticoagulation for patients undergoing cardioversion for atrial fibrillation, implementation of an algorithm guiding appropriate $P2Y_{12}$ inhibitor selection in ACS, provision of order set review and optimization, and inclusion of a pharmacist consult for anticoagulation and antiplatelet management on our order set following placement of a left atrial appendage occlusion device. Further study is needed to quantify these advances.

While the interventions quantified in this study were not performed under a collaborative practice agreement and required pharmacist outreach to the medical team, a collaborative practice agreement that will allow the CCL pharmacist to modify lipid-lowering therapies is forthcoming; this may facilitate further optimization of this component of GDMT. Provider satisfaction with this position has not been objectively evaluated, but anecdotal evidence reflects a high level of provider satisfaction with a dedicated pharmacist on the CCL team. No financial outcomes were assessed in this study, but prior studies have shown that pharmacist involvement on the care team results in improved patient outcomes and cost-effective care.[7] Additionally, there is a potential for revenue generation through increased utilization of our onsite pharmacy, which was previously underutilized.

Limitations of this study included the inherent selection bias that is associated with retrospective chart review. There was also the possibility of missing or inadequate documentation, as this chart review relied on accurate information being present in the medical record. Additionally, the timeframes were chosen to minimize the effect of COVID-19 on elective procedures, but there were several years between the pre- and postimplementation periods. It is possible that changes in organizational leadership and policies over these years could have influenced the changes in outcomes seen. Some patients in the preimplementation period may not have stayed overnight and therefore did not have a pharmacist review their discharge medications, which may be an inappropriate comparison to the postimplementation period in which a pharmacist reviewed all discharges. Only the quantity of pharmacist interventions was assessed, and the appropriateness of these interventions or potentially missed opportunities for intervention were not assessed. This is especially important when considering the rates of high-intensity statin therapy, as some patients may refuse to start or increase the dose of a statin, which was not assessed in our study. DAPT regimens for patients on anticoagulation were also not assessed for appropriateness and these patients were included in the general analysis, although they could represent a population that potentially should receive only a short course of DAPT. Finally, the incidence of long-term outcomes such as stent thrombosis and bleeding events as well as patient adherence were not assessed, so conclusions cannot be drawn regarding the relationship between improved GDMT prescribing and patient outcomes.

Conclusion

Overall, pharmacists' unique training offers a wide variety of opportunities to enhance care for patients undergoing procedures in the CCL. In particular, designating a pharmacist to work exclusively in the CCL allows them to become proficient in chart review and identify key opportunities to enhance a patient's medication regimen after a variety of CCL procedures. Our study provides evidence that pharmacy presence is associated with higher rates of high-intensity statin therapy and lower rates of esomeprazole or omeprazole use with clopidogrel following PCI. To our knowledge, these are the first data published regarding the objective benefit of pharmacist presence in the CCL. The opportunities for clinical pharmacists and pharmacy technicians continue to expand, and pharmacy presence in the CCL has measurable benefits to patients as shown in this study. These data highlight the integral role of pharmacists as a member of the cardiac care team.

Data availability

The data that support the findings of this study are not publicly available due to their containing information that could compromise the privacy of research participants.

Disclosures

Dr. Ritchie is employed by Chiesi. Dr. Ritchie's contribution is not related to work performed as a Chiesi employee, and Chiesi did not fund or support the manuscript or publication. The remaining authors have declared no potential conflicts of interest.

Additional information

This work was presented as a poster at the American College of Clinical Pharmacy Annual Meeting, held in November 2023 in Dallas, TX.

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