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ORIGINAL RESEARCH ARTICLE

Optimising Medications in Older Vascular Surgery Patients Through Geriatric Co-management

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Abstract

Background Prescribing of potentially inappropriate medications and under-prescribing of guideline-recommended medications for cardiovascular risk modification have both been associated with negative outcomes in older adults. Hospitalisation represents an important opportunity to optimise medication use and may be achieved through geriatrician-led interventions.
Objective We aimed to evaluate whether implementation of a novel model of care called Geriatric Comanagement of older Vascular (GeriCO-V) surgery patients is associated with improvements in medication prescribing.
Methods We used a prospective pre-post study design. The intervention was a geriatric co-management model, where a geriatrician delivered comprehensive geriatric assessment-based interventions including a routine medication review. We included consecutively admitted patients to the vascular surgery unit at a tertiary academic centre aged ≥ 65 years with an expected length of stay of ≥ 2 days and who were discharged from hospital. Outcomes of interest were the prevalence of at least one potentially inappropriate medication as defined by the Beers Criteria at admission and discharge, and rates of cessation of at least one potentially inappropriate medication present on admission. In the subgroup of patients with peripheral arterial disease, the prevalence of guideline-recommended medications on discharge was determined.
Results There were 137 patients in the pre-intervention group (median [interquartile range] age: 80.0 [74.0–85.0] years, 83 [60.6%] with peripheral arterial disease) and 132 patients in the post-intervention group (median [interquartile range] age: 79.0 (73.0–84.0) years, 75 [56.8%] with peripheral arterial disease). There was no change in the prevalence of potentially inappropriate medication use from admission to discharge in either group (pre-intervention: 74.5% on admission vs 75.2% on discharge; post-intervention: 72.0% vs 72.7%, $p = 0.65$). Forty-five percent of pre-intervention group patients had at least one potentially inappropriate medication present on admission ceased, compared with 36% of post-intervention group patients ($p = 0.11$). A higher number of patients with peripheral arterial disease in the post-intervention group were discharged on antiplatelet agent therapy (63 [84.0%] vs 53 [63.9%], $p = 0.004$) and lipid-lowering therapy (58 [77.3%] vs 55 [66.3%], $p = 0.12$).
Conclusions Geriatric co-management was associated with an improvement in guideline-recommended antiplatelet agent prescribing aimed at cardiovascular risk modification for older vascular surgery patients. The prevalence of potentially inappropriate medications was high in this population, and was not reduced with geriatric co-management.

1 Background

Older patients take multiple medications to manage multiple comorbidities [1] and demonstrate a disproportionate intrinsic susceptibility to adverse drug events [2]. Appropriately prescribed medications have benefits, for example, vascular surgery patients with peripheral arterial disease (PAD) who receive medical management with an antiplatelet agent and

Key Summary Points

Geriatric co-management was associated with an improvement in guideline-recommended antiplatelet agent prescribing aimed at cardiovascular risk modification for older vascular surgery patients.

Prevalence of potentially inappropriate medications was high in an older surgical population.

Prevalence of potentially inappropriate medication was not reduced with geriatric co-management.

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statin have improved 5-year survival [3]. However, studies have reported suboptimal use of guideline-recommended medical therapy, especially among older individuals [4–6]. Furthermore, some medications may be harmful in older adults, which has led to the recognition of potentially inappropriate medications (PIMs). Potentially inappropriate medications are medications that have an unfavourable risk-benefit profile in most older patients and typically should be avoided because of their increased risk of adverse drug events such as falls, confusion, functional decline, hospitalisation, increased healthcare costs and mortality [7–10]. Potentially inappropriate medications can be identified by established consensus criteria such as the American Geriatrics Society Beers Criteria [11]. Management of medications in older adults is often challenging and requires balancing their risks and benefits.

The hospital admission provides an important opportunity to initiate appropriate medications and deprescribe PIMs in older adults [12]. Medication optimisation is a core component of a comprehensive geriatric assessment and management, and hence a geriatric co-management model may be an effective means to improve medication prescribing in hospitalised adults undergoing surgery. While there is a growing evidence base for the benefits of geriatric co-management of surgical patients, few of these studies have examined the impact of such models on prescribing patterns and the prevalence of PIMs [13]. To address these knowledge gaps, we investigated the prescribing patterns of PIMs and guideline-recommended medical therapy for PAD before and after the introduction of a geriatric co-management model of care for hospitalised older vascular surgery patients.

2 Methods

2.1 Study Population and Design

Design was a prospective pre-post study conducted at Concord Hospital, Sydney, NSW, Australia to determine the effectiveness of a new geriatric co-management model of care for older vascular surgery patients. The vascular surgery unit admits and treats a variety of conditions with operative and/or non-operative management, including but not limited to wound care, aneurysmal disease and peripheral vascular disease. Operative management also includes both elective and emergent admissions. The study methods and primary outcomes have previously been published [14]. Patients were recruited for the pre-intervention phase between February and October 2019 followed by a 2-month intervention implementation period. Recruitment for the post-intervention phase occurred between January and December 2020. Patients consecutively admitted for operative (emergency or elective) or non-operative management under the vascular surgery service were eligible for inclusion if they were aged ≥ 65 years with an expected length of stay greater than 2 days. Patients were excluded if they were admitted for day-only procedures or were transferred from another inpatient specialty. This study examined secondary medication outcomes in the original study cohort after excluding patients who died during their hospital admission or were transferred to another speciality team at the hospital. The study was granted approval by the Sydney Local Health District Human Research Ethics Committee (CH62/6/2018-170). A waiver of informed consent for data collection from medical records and an opt-out process for face-to-face cognition assessment were approved.

2.2 Intervention

The intervention was the introduction of a co-management model of care, called the Geriatric Comanagement of older Vascular (GeriCO-V) surgery patients. In the GeriCO-V model, a geriatrician was included as part of the vascular surgery team and proactively performed a comprehensive geriatric assessment including routine medication review for all vascular surgery patients aged 65 years or older. Medication review involved medication reconciliation at admission, regular review of inpatient medications during ward rounds, identification of PIMs, and the implementation of appropriate and tailored prescribing and deprescribing interventions throughout the patient's hospitalisation. Geriatrician reviews occurred twice weekly on joint ward rounds with the surgical resident and vascular specialist nurse. The geriatrician also attended the weekly vascular surgery multidisciplinary team meeting and a mid-week virtual patient journey board meeting. The geriatrician provided education to the team on medication reconciliation and PIM identification and deprescribing. The vascular surgeons and geriatrician developed a discharge summary checklist that included the prescription of guideline-recommended medications for patients with PAD. Clinical pharmacy consultation was available upon request from medical or nursing staff during both the pre- and post-intervention periods.

2.3 Standard Care

Prior to implementation of the GeriCO-V model, a geriatrician review was available to vascular surgery patients via ad hoc referral from the vascular surgery team to the on-call geriatric medicine team. Medication review did not occur routinely by a clinician. A medication history was variably recorded at the time of admission by the emergency department and/or vascular surgery team. Clinical pharmacy review did not always occur, but the surgical team could request a pharmacist-led best possible medication history and

comprehensive medication review. Surgical residents did not receive formal teaching on medication review or PIMs.

2.4 Data Collection

Data including demographic, operation and medication data were sourced from the patient's electronic medical record documentation by trained research assistants. Cognitive impairment and frailty status were assessed face to face on admission via trained clinical researchers using the Abbreviated Mental Test Score and Clinical Frailty Scale, respectively [15, 16]. Patients with PAD were identified as patients with a documented pre-existing diagnosis of PAD or a new diagnosis of PAD during the admission based on clinical, radiological, ultrasound and operation parameters. Peripheral arterial disease was defined as acute or chronic ischaemia of lower extremity arterial segments and did not include patients with only aneurysmal disease of the abdominal aorta or carotid disease.

2.5 Outcomes

Outcomes of interest were changes in clinician prescribing practices pre- and post-intervention by examining:

(1) the prevalence of exposure to at least one PIM at admission and discharge as defined by Beers Criteria [11];
(2) rates of cessation of at least one PIM as defined by Beers Criteria [11]; and
(3) rates of prescription of an anti-platelet lipid-lowering agent and anti-hypertensive agent in patients with PAD as per the 2016 American Heart Association/American College of Cardiology Guideline on the Management of Patients With Lower Extremity Peripheral Artery Disease [17].

Exposure to PIMs was defined as the presence of at least one regular or as-required medication that was listed on the 2019 Beers Criteria [11]. The types of PIMs by class and specific medications were also characterised in this older surgical cohort.

2.6 Statistical Analysis

Baseline characteristics of the pre- and post-intervention groups were expressed as frequencies for categorical data and mean or median for continuous variables. The number of PIMs per patient was calculated on admission and discharge, as well as the number of patients with a reduction in PIMs on discharge. The medications and medication classes that most frequently contributed to PIMs on admission and discharge were also determined. Comparisons of changes in exposure to PIMs and prescribing practices between groups were performed by Chi-square or Fisher's exact tests for categorical variables and by the unpaired t test or Mann–Whitney U Test for continuous data. Descriptive statistics were reported for medications and classes contributing to PIMs on admission and discharge.

3 Results

3.1 Patient Characteristics

There was a total of 137 patients in the pre-intervention group and 132 patients in the post-intervention group. The groups were similar in terms of sociodemographic characteristics and comorbidities (Table 1). Non-operative management and frailty were more prevalent in the post-intervention group. There was a high use of medications in both groups, with over 80% of patients taking at least five regular medications on admission.

3.2 Exposure to PIMs

Total medication use increased from admission to discharge in both groups (Table 2). The prevalence of exposure to at least one PIM remained similar at discharge compared to admission in the pre- and post-intervention groups, 74.5% on admission versus 75.2% on discharge, and 72.0% on admission versus 72.7% on discharge, respectively ($p = 0.65$). On discharge, there was no significant difference in the mean (standard deviation) number of PIMs in the post-intervention group compared to the pre-intervention group (− 0.03 [0.81] vs 0.07 [0.79], $p = 0.36$). There was a non-significant trend towards more patients with at least one PIM ceased in the post-intervention group compared with the pre-intervention group (60 [45.5%] vs 49 [35.8%], $p = 0.11$). At least one PIM was ceased or dose reduced in 16% and 18% of the pre- and post-intervention cohorts, respectively.

The most common PIMs and medication classes that contributed to PIMs on admission and discharge were similar in the pre- and post-intervention groups, as shown in the table in the Electronic Supplementary Material. The most common classes of PIMs on admission and discharge in both groups were proton pump inhibitors, diuretics and opioids. The most commonly prescribed new PIMs in the pre-intervention cohort were opioids, proton pump inhibitors and anti-epileptic drugs (pregabalin). In the post-intervention cohort, these were opioids, anti-epileptic drugs and antiplatelet agents. The most commonly ceased PIMs were diuretics and opioids in both cohorts.

Table 1 Participant characteristics

Characteristic	Pre-intervention (n = 137)	Post-intervention (n = 132)	p-value
Sociodemographic			
Age, median (IQR)	80.0 (74.0–85.0)	79.0 (73.0–84.0)	0.40
Male, *n* (%)	92 (67.2)	87 (65.9)	0.82
CALD, *n* (%)	43 (31.4)	39 (29.5)	0.74
Residential aged care resident, *n* (%)	16 (11.7)	21 (15.9)	0.31
Current or ex-smoker, *n* (%)	78 (59.5)	74 (57.4)	0.72
Clinical			
Emergency admission, *n* (%)	49 (35.8)	58 (43.9)	0.17
Underwent operative management, *n* (%)	109 (79.6)	89 (67.4)	0.02
Open (vs endovascular only) procedure, *n* (%)	55 (50.5)	49 (55.1)	0.52
Emergency (vs elective) procedure, *n* (%)	26 (23.9)	32 (36.0)	0.06
Charlson Comorbidity Index score, median (IQR)	3.0 (2.0–5.0)	3.0 (1.0–4.0)	0.54
Diabetes mellitus, *n* (%)	62 (45.3)	60 (45.5)	0.97
Renal impairment, *n* (%)	41 (29.9)	41 (31.1)	0.84
Pre-existing or new diagnosis of peripheral arterial disease	83 (60.6)	75 (56.8)	0.53
Pre-existing hypertension	113 (82.5)	102 (77.3)	0.29
Cardiovascular disease	80 (58.4)	89 (67.4)	0.13
No. of regular medications, median (IQR)	7.0 (5.0–9.5)	9.0 (6.0–12.0)	<0.001
Geriatric syndromes			
Frail (CFS >4), *n* (%)	41 (29.9)	54 (40.9)	0.06
Functional dependence (in ≥1 ADL), *n* (%)	44 (32.1)	46 (34.8)	0.64
Cognitive impairment (dementia diagnosis or AMTS score < 8), *n* (%)	47 (36.7)	40 (32.5)	0.48
Assisted mobility, *n* (%)	17 (12.4)	19 (14.4)	0.63
History of falls, *n* (%)	49 (35.8)	59 (44.7)	0.14
Polypharmacy[a] (> 4 regular medications)	113 (82.5)	112 (84.8)	0.60

ADL activities of daily living, *AMTS* Abbreviated Mental Test Score, *CALD* culturally and linguistically diverse, *CFS* Clinical Frailty Score, *IQR* interquartile range

[a]Polypharmacy was defined as the use of five or more regularly administered medications, excluding vitamins and mineral supplements, 'as required' medications and medications administered via topical, vaginal, rectal, nasal, otic or ophthalmological routes

3.3 Prescribing of Guideline-Recommended Medical Therapy for PAD

There was a total of 158 patients with pre-existing or newly diagnosed PAD. A significantly higher proportion of patients with PAD in the post-intervention group were discharged on an antiplatelet agent (62 [82.7%] vs 52 [62.7%], $p = 0.005$), and a non-significant increase was observed in the proportion of patients discharged on a lipid-lowering agent (58 [77.3%] vs 55 [66.3%], $p = 0.12$), see Table 3. There was no difference in the rates of anti-hypertensive agents at discharge (61 [81.3%] vs 66 [79.5%], $p = 0.77$).

4 Discussion

There is a growing number of older adults with ageing physiology, polypharmacy, frailty and multimorbidity undergoing surgery [18, 19]. The perioperative period provides an important window of opportunity to implement a comprehensive medication review and interventions to address under-prescribing and high-risk prescribing such as polypharmacy and PIMs. Our study found that the introduction of a geriatric co-management model of care for older vascular surgery patients in hospital improved the prescribing of guideline-recommended antiplatelet agents for PAD but had no significant impact on exposure to PIMs. We also demonstrated the complexity of patients in an acute surgical care setting. The cohort of older vascular surgery patients had vascular comorbidities as well as prevalent geriatric syndromes such as frailty, highlighting the need for geriatric co-management models of care to assist with rationalising medications and addressing under-prescribing.

We found no significant reduction in the exposure to PIMs after introduction of geriatric co-management. In our study, medication optimisation interventions including deprescribing were delivered as part of a new proactive geriatric co-management model of care. A recent systematic review

Table 2 Medication use and exposure to PIMs

	Pre-intervention ($n = 137$)	Post-intervention ($n = 132$)	p-value
PIM exposure[a]			
Prevalence of ≥1 PIM use admission vs discharge, *n* (%)	74.5% vs 75.2%	72.0% vs 72.7%	0.65
Admission vs discharge, mean (SD)	1.6 (1.6) vs 1.6 (1.6)	1.6 (1.5) vs 1.5 (1.4)	0.36
Deprescribing of PIMs			
At least one PIM ceased, *n* (%)	19 (13.9)	24 (18.2)	0.34
At least one PIM dose reduced, *n* (%)	7 (5.1)	6 (4.5)	0.83
Reduction in total PIMs at discharge, *n* (%)	15 (10.9)	18 (13.6)	0.50
Regular medications			
Admission vs discharge, mean (SD)	7.3 (3.1) vs 7.9 (3.2)	9.5 (4.9) vs 10.7 (4.4)	0.014
At least one medication ceased, *n* (%)	49 (35.8)	60 (45.5)	0.11
At least one medication dose reduced, *n* (%)	26 (19.0)	36 (27.3)	0.11

PIM potentially inappropriate medication, *SD* standard deviation

[a]Creatinine clearance was unable to be calculated in 10 of 137 participants in the pre-intervention cohort and 32 of 132 participants in the post-intervention cohort because of weight not being recorded. Any PIMs related to creatinine clearance were not assessed in these patients

Table 3 Prescription of guideline-recommended medications for cardiovascular risk modification amongst patients with PAD

	Pre-intervention and presence of PAD ($n = 83$)	Post-intervention and presence of PAD ($n = 75$)	p-value[a]
Anti-hypertensive agent, *n* (%)	Admission: 71 (85.5)	Admission: 63 (84.0)	0.77
	Discharge: 66 (79.5)	Discharge: 61 (81.3)	
Antiplatelet agent, *n* (%)	Admission: 45 (54.2)	Admission: 55 (73.3)	0.005
	Discharge: 52 (62.7)	Discharge: 62 (82.7)	
Statin or fibrate, *n* (%)	Admission: 52 (62.7)	Admission: 54 (72.0)	0.12
	Discharge: 55 (66.3)	Discharge: 58 (77.3)	

PAD peripheral arterial disease

[a]*p*-value refers to statistical significance on comparing rates at discharge across both groups

found that only a minority of studies evaluating deprescribing interventions in older adults undergoing surgery showed a difference in medication changes between the intervention and control groups, and few deprescribing interventions changed outcomes of quality of life, function, mortality and post-operative complications [20]. Yet, we observed that in the geriatrician co-managed group, 18% of patients had a least one PIM ceased/dose reduced and 73% had at least any regular medication ceased/dose reduced, demonstrating that deprescribing can be implemented in most patients during an acute surgical admission. Our study was not able to demonstrate that deprescribing these medications was associated with improved clinical outcomes. The few other studies of geriatric co-management in surgical patients have also not shown that improvements in clinical outcomes were associated with changes in medication prescriptions and this remains an evidence gap [21].

We found no changes in specific PIMs or classes of PIMs after implementation of the geriatric co-management model of care. Of note, the most frequent newly prescribed medications included opioids and pregabalin in both the pre- and post-intervention groups. This most likely reflects the types of pain in vascular surgery patients including ischaemic, neuropathic, phantom limb or stump and wound-related pain that may not have resolved post-surgery and requires ongoing analgesic use [22]. International guidelines recommend opioids as first line for the management of severe pain in chronic limb-threatening ischemia [23]. Further, pain can be a treatable cause of delirium and hence there may be an appropriate role for the prescribing of opioids and opioid-sparing analgesia in this population [24, 25].

Not all PIMs are equally likely to cause clinically significant harm. Certain drugs are more frequently associated with adverse drug reactions, including digoxin, antidiabetic agents and non-steroidal anti-inflammatory drugs [26].

Specific classes of PIMs have also been associated with worse outcomes in hospitalised surgical patients [27, 28]. The authors of the Beers criteria remind clinicians that the medications identified using the criteria are only potentially inappropriate, not always inappropriate [29]. For example, there were high rates of opioid prescription during admission, representing up to 48.6% of all new PIMs, for which a majority are likely to be clinically justified in the context of acute ischaemic pain or post-operative pain. Similarly, proton pump inhibitors, a suggested class for deprescribing [30], represented 14.3% of all new PIMs in our cohort, and this may reflect clinician concerns about the risk of gastrointestinal bleeding in older patients with PAD who are taking at least one antiplatelet agent and/or anticoagulant. Our findings highlight that in older patients with complex multimorbidity, the presence of PIMs and polypharmacy may not always be associated with worse outcomes if the therapeutic benefits are justified, and potential adverse effects are appropriately monitored. A Cochrane systematic review of interventions to improve the appropriate use of polypharmacy in patients aged ≥65 years found that while interventions have demonstrated reduced inappropriate prescribing, they did not necessarily consider the appropriateness of prescribing and the clinical impact of reducing PIMs is unknown [31].

Under-prescribing is another reason for a potentially suboptimal medication regime [32]. We observed a higher number of patients with PAD in the post-intervention group were discharged on antiplatelet agent and lipid-lowering therapy following implementation of the geriatric co-management model. Previous studies have demonstrated a beneficial effect of antiplatelet agent and statin prescriptions in older adults with arterial disease, with improvements in 1- and 5-year survival [3, 5]. However, these studies also showed an under-prescription of antiplatelet agents and statins in these older patients. Under-prescription may be related to the initial paucity of evidence to guide the use of these medicines in older and comorbid adults, who are frequently excluded from drug trials. Studies of populations of older patients found that prescription of guideline-recommended drugs in cardiovascular disease is associated with better clinical outcomes, independent of geriatric syndromes [33, 34]. Prescribing of guideline-recommended therapies in an older adult requires shared decision making that considers their healthcare-related goals.

The post-intervention study period coincided with the onset of the coronavirus disease 2019 pandemic. In Australia, there was a government-mandated temporary cancellation of all non-urgent elective surgical procedures in response to coronavirus disease 2019, which resulted in decreases in total vascular procedures and vascular elective procedures, and was associated with an increase in emergency procedures (especially revascularisation operations for critical limb ischemia) compared with the years prior to the onset of coronavirus disease 2019 [35]. This may explain the trend seen in our study with more patients in the post-intervention cohort having emergency admissions, being more frail and undergoing an emergency procedure. These factors may have influenced medication prescribing, for example, the higher number of patients presenting with critical limb ischaemia may have resulted in increased prescribing of analgesics on discharge.

4.1 Limitations and Strengths

There are limitations with applying the Beers Criteria, which is based on the American formulary, in an Australian context. It has been previously noted that the adverse drug events associated with PIMs identified using the Beers Criteria are more evident in older American individuals than elsewhere, likely owing to the differences in formulary and local prescribing practices [26]. There are also other PIMs not addressed in the Beers Criteria but relevant to an older vascular surgery cohort that were not evaluated in this study, for example, dual antiplatelet therapy and combination antiplatelet and anticoagulant therapy. The Beers Criteria also does not take into account the dose or frequency of prescribed PIMs. Other tools such as the Drug Burden Index [36] could be of relevance to evaluate if there were reductions in medication doses without cessation of the medication. This study was not powered to examine associations between the prescription of guideline-recommended medications and clinical outcomes, nor between exposure to PIMs and clinical outcomes. This study was conducted in a single centre, which limits generalisability.

The strengths of this study are that it is one of a few studies that examined the impact of a geriatrician-led medication review in the inpatient setting. The sample size is comparable, if not larger than other deprescribing studies conducted in medical and surgical older inpatients [12, 20]. The identification of PIMs using the Beers Criteria was completed and verified by two investigators.

5 Conclusions

In this study, the introduction of a geriatric co-management model of care with a routine medication review and interventions improved guideline-recommended prescribing for older vascular surgery patients with PAD. There was no significant reduction in exposure to PIMs but over 50% of patients had at least one regular medication ceased in the acute surgical setting. The implementation of a novel model of geriatric co-management for older surgical patients was an effective means to improve some prescribing practices

but further research is needed to determine the impact on deprescribing measures and clinical outcomes.

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Declarations

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Conflicts of Interest/Competing Interests Jeff Wang, Sophie James, Sarah N. Hilmer, Sarah J. Aitken, Garry Soo, Vasi Naganathan, Leanne Kearney and Janani Thillainadesan have no conflicts of interest that are directly relevant to the content of this article.

Ethics Approval The study was granted approval by the Sydney Local Health District Human Research Ethics Committee (CH62/6/2018-170).

Consent to Participate This study evaluated a model of care that was implemented as the new standard of clinical practice at the hospital. A waiver of informed consent for data collection from medical records and an opt-out process for face-to-face cognition assessment were approved by the local human research ethics committee.

Consent for Publication Not applicable.

Availability of Data and Material The datasets generated and/or analysed during the current study are available from the corresponding author upon reasonable request.

Code Availability Not applicable.

Authors' Contributions Study concept and design: JT, VN, SNH. Acquisition of data/analysis and interpretation of data: JT, JW, SJ, SNH, SJA, GS, VN, LK. Drafting of the manuscript: JT, JW, SJ, SNH, SJA, GS, VN, LK. Critical revision of the manuscript for important intellectual content: JT, JW, SJ, SNH, SJA, GS, VN, LK.

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