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Original Article

# Readmissions After Left Atrial Appendage Closure in Patients With Previous Ischemic Stroke or Transient Ischemic Attack

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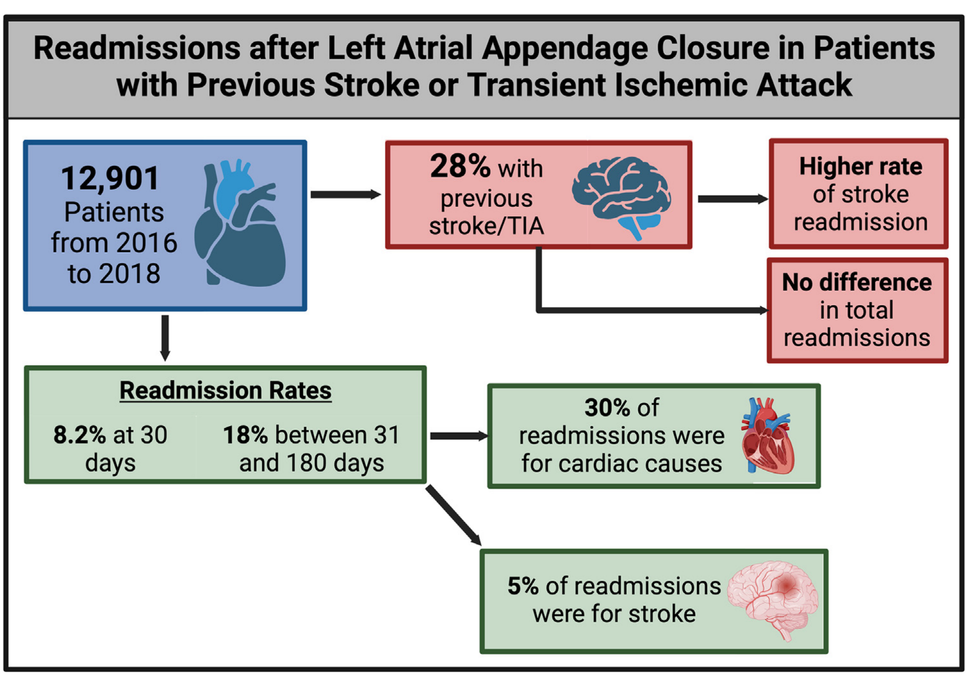


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## ABSTRACT

**Background:** We examined the frequency and risk factors associated with readmission after left atrial appendage closure (LAAC) in patients with and without previous ischemic stroke and/or transient ischemic attack (TIA).

**Methods:** Hospitalizations for LAAC were identified from the US National Readmission Database, 2016-2018. The primary outcome was the first unplanned readmission after LAAC, with readmission times stratified into those occurring within 0 to 30 days vs within 31 to 180 days. Patients were stratified based on the history of previous stroke and/or TIA.

**Results:** Of 12,901 discharges after LAAC, 28% had previous stroke and/or TIA, and 8.2% had a readmission within 30 days while 18% had a readmission within 31 to 180 days. The rates of in-hospital complications and readmissions at both periods were not significantly different between individuals with vs without previous stroke and/or TIA. Cardiac causes accounted for 28% of readmissions within 30 days and 32% of those within 31 to 180 days, and congestive failure, bleeding, and infections were the most common readmission diagnoses. New stroke and/or TIA accounted for 4% and 6% of the total noncardiac readmissions within 30 days and 31 to 180 days, respectively, and the incidence was higher among those with previous stroke and/or TIA. Female sex and index hospitalization length of stay (LOS) > 1 day were factors independently associated with readmission within 30 days, whereas LOS, diabetes, renal disease, chronic obstructive pulmonary disease, and anemia were among the factors associated with readmissions within 31 to 180 days.

**Conclusions:** Unplanned rehospitalizations were common after LAAC and had similar frequency for patients with vs without previous ischemic stroke and/or TIA. Female sex and index hospitalization LOS > 1 day were among the strongest factors that were independently associated with readmission within 30 days.

## RÉSUMÉ

**Contexte :** Nous avons examiné la fréquence et les facteurs de risque des réadmissions consécutives à une fermeture de l'appendice auriculaire gauche (FAOG) chez les patients ayant ou non subi un accident vasculaire cérébral (AVC) ischémique et/ou un accident ischémique transitoire (AIT).

**Méthodologie :** Les hospitalisations pour une FAOG ont été recensées au moyen de la *US National Readmission Database* (base de données nationale des réadmissions aux États-Unis) pour la période 2016-2018. Le critère d'évaluation principal était la première réadmission non prévue après une FAOG, avec stratification du moment de la réadmission selon que celle-ci était survenue de 0 à 30 jours ou de 31 à 180 jours après l'intervention. Les patients ont été stratifiés en fonction des antécédents d'AVC et/ou d'AIT.

**Résultats :** Parmi les 12 901 patients ayant reçu leur congé de l'hôpital après une FAOG, 28 % avaient des antécédents d'AVC et/ou d'AIT; 8,2 % des patients admissibles ont été réadmis dans les 30 jours et 18 %, entre le 31e et le 180e jour suivant l'intervention. Aucune différence significative n'a été observée entre les patients ayant subi un AVC et/ou un AIT et les patients qui n'en avaient pas subi en ce qui concerne les taux de complications hospitalières et de réadmission durant ces deux périodes. Les causes cardiaques représentaient 28 % des réadmissions dans les 30 jours et 32 % des réadmissions entre le 31e et le 180e jour. L'insuffisance cardiaque congestive, les hémorragies et les infections ont été les causes les plus fréquentes de réadmission. Les nouveaux cas d'AVC et/ou d'AIT ont respectivement été à l'origine de 4 % et de 6 % de l'ensemble des réadmissions de cause non cardiaque dans les 30 jours, et entre le 31e et le 180e jour, et leur fréquence a été plus élevée chez les patients ayant des antécédents d'AVC et/ou d'AIT. Le sexe féminin et une durée d'hospitalisation initiale > 1 jour ont été des facteurs indépendants associés aux réadmissions dans les 30 jours, tandis que la durée de l'hospitalisation, un diabète, une néphropathie, une maladie pulmonaire obstructive chronique et une anémie faisaient partie des facteurs associés aux réadmissions entre le 31e et le 180e jour.

**Conclusions :** Les réhospitalisations non prévues ont été courantes après une FAOG, et leur fréquence a été similaire en présence ou en l'absence d'antécédents d'AVC ischémique et/ou d'AIT. Le sexe féminin et une durée d'hospitalisation initiale > 1 jour ont été les facteurs les plus importants associés aux réadmissions dans les 30 jours.

Although oral anticoagulant therapy is the first-line treatment for stroke prevention in patients with nonvalvular atrial fibrillation, many patients have contraindications, such as the increased risk of bleeding, and cannot safely take these medications. In these situations, left atrial appendage closure (LAAC) has emerged as an effective method to reduce stroke risk.[1]

The rate of readmission after cardiac procedures is recognized as an important quality-of-care and economic metric. Given that the rate of in-hospital mortality after LAAC is low, readmissions after LAAC may represent an important area for improvement in postprocedural management. The frequency and causes of readmission after percutaneous coronary intervention[2,3] and cardiac surgery[4] have been well studied, but significantly less such research has been conducted for LAAC. Given that patients referred for LAAC procedures often present with a previous history of ischemic stroke and/or transient ischemic attack (TIA), whether these patients are at a higher risk of early or midterm events that may predispose them to readmission after LAAC is unclear. Therefore, this study aimed to examine both the rate of 30-day and 31 to 180−day unplanned readmissions, along with the causes and factors associated with such readmission after LAAC, in patients with and without previous ischemic stroke and/or TIA.

## Methods

The National Readmission Database (NRD) is a nationally representative all-payer database of hospital discharges in the

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See page 963 for disclosure information.

**Table 1.** **Baseline characteristics of the entire study population**

| Patient characteristics | All (N = 12,901) | With previous stroke and/or TIA (n = 3572) | Without previous stroke and/ or TIA (n = 9329) | Adjusted *P* ** |
|---|---|---|---|---|
| Age, y | 77 (71–82) | 77 (71–82) | 77 (71–82) | 0.69 |
| Sex, male | 7467 (58) | 1986 (56) | 5481 (59) | **0.002** |
| Median household income percentile* | | | | |
| 0–25th | 2658 (21) | 710 (20) | 1948 (21) | 0.64 |
| 26–50th | 3259 (26) | 878 (25) | 2381 (26) | |
| 51–75th | 3608 (28) | 1026 (29) | 2582 (28) | |
| 76–100th | 3222 (25) | 920 (26) | 2302 (25) | |
| Medicare payer† | 11,486 (89) | 3139 (88) | 8347 (90) | 0.17 |
| Urban patient location‡ | 11,086 (86) | 3103 (87) | 7983 (86) | 0.26 |
| Hospital teaching status | | | | |
| Urban nonteaching | 1410 (11) | 374 (10) | 1036 (11) | 0.10 |
| Urban teaching | 11,351 (88) | 3169 (89) | 8182 (88) | |
| Rural | 140 (1.1) | 29 (0.8) | 111 (1.2) | |
| Hospital bed volume | | | | |
| Small | 782 (6.1) | 198 (5.5) | 584 (6.3) | 0.07 |
| Medium | 2839 (22) | 758 (21) | 2081 (22) | |
| Large | 9280 (72) | 2616 (73) | 6664 (71) | |
| Comorbidities | | | | |
| Dyslipidemia | 7833 (61) | 2281 (64) | 5552 (60) | **< 0.001** |
| Renal disease | 2773 (21) | 728 (20) | 2045 (22) | 0.05 |
| CABG | 1818 (14) | 484 (14) | 1334 (14) | 0.29 |
| PCI | 2129 (17) | 568 (16) | 1561 (17) | 0.23 |
| Hypertension | 11,169 (87) | 3124 (87) | 8045 (86) | 0.11 |
| Diabetes mellitus | 4442 (34) | 1250 (35) | 3192 (34) | 0.58 |
| Obesity | 2130 (17) | 526 (15) | 1604 (17) | **< 0.001** |
| Smoking | 4279 (33) | 1236 (35) | 3043 (33) | **0.01** |
| Congestive heart failure | 4959 (38) | 1229 (34) | 3730 (40) | **< 0.001** |
| Myocardial infarction | 1518 (12) | 443 (12) | 1075 (12) | 0.10 |
| Peripheral vascular disease | 1277 (9.9) | 397 (11) | 880 (9.4) | **0.004** |
| Valvular heart disease | 2724 (21) | 736 (21) | 1988 (21) | 0.22 |
| COPD | 2719 (21) | 698 (20) | 2021 (22) | **0.03** |
| Liver disease | 364 (2.8) | 88 (2.5) | 276 (3.0) | 0.11 |
| Dementia | 385 (3.0) | 142 (4.0) | 243 (2.6) | **< 0.001** |
| Hypothyroidism | 2018 (16) | 559 (16) | 1459 (16) | 0.92 |
| Coagulopathy | 469 (3.6) | 117 (3.3) | 352 (3.8) | 0.19 |
| Cancer | 320 (2.5) | 88 (2.5) | 232 (2.5) | 0.84 |
| Anemia | 932 (7.2) | 231 (6.5) | 701 (7.5) | **0.04** |
| Charlson Comorbidity Index | 2 (1–3) | 2 (1–4) | 1 (1–3) | **< 0.001** |
| Elixhauser Comorbidity Score | 8 (5–13) | 9 (5–13) | 8 (5–13) | 0.59 |
| $CHA_2DS_2$-VASc score | 4 (3–5) | 6 (5–7) | 4 (3–4) | **< 0.001** |
| Hospital frailty risk score | 1.5 (0.4–3.3) | 1.5 (0–3) | 2 (0.5–4.3) | **< 0.001** |
| Year of procedure (January –December) | | | | |
| 2016 | 1241 (9.6) | 358 (10) | 883 (9.5) | 0.48 |
| 2017 | 2321 (18) | 657 (18) | 1664 (18) | |
| 2018 | 9339 (72) | 2557 (72) | 6782 (73) | |
| In-hospital adverse events, index admission | | | | |
| Total major adverse events | 671 (5.2) | 178 (5.0) | 493 (5.3) | 0.41 |
| Cardiac complications | 278 (2.2) | 66 (1.8) | 212 (2.3) | 0.16 |
| Bleeding complications | 172 (0.7) | 62 (0.7) | 86 (0.7) | 0.88 |

| | | | | |
|---|---|---|---|---|
| Vascular complications | 50 (0.4) | 16 (0.4) | 34 (0.4) | 0.69 |
| Stroke and/or TIA | 51 (0.4) | 24 (0.7) | 27 (0.3) | **0.01** |
| Acute kidney injury | 304 (2.4) | 81 (2.3) | 223 (2.4) | 0.63 |
| Death | 22 (0.2) | < 11 (0.1) | 19 (0.2) | 0.07 |
| Length of stay, d | 1 (1-1) | 1 (1-1) | 1 (1-1) | **0.02** |
| ≤ 1 | 11,339 (88) | 3098 (87) | 8241 (88) | **0.03** |
| > 1 | 1562 (12) | 474 (13) | 1088 (12) | |
| Total index cost, USD$§ | 25,250 (18,847−30,825) | 25,332 (18,944−30,711) | 25,188 (18,794−30,847) | 0.45 |
| Readmission rates | | | | |
| 0−30 d‖ | 958 (8.2) | 278 (8.5) | 680 (8.1) | 0.26 |
| 31−180 d¶ | 959 (18) | 283 (20) | 676 (18) | 0.17 |

Values are expressed as median (interquartile range) or count (%), unless otherwise indicated. Boldface indicates statistical significance. Some percentages may not add up to 100%, owing to rounding. Exact counts for variables with < 11 patients are not detailed, per the Healthcare Cost and Utilization Project data use agreement.

CABG, coronary artery bypass grafting; $CHA_2DS_2$-VASc, **C**ongestive Heart Failure, **H**ypertension, **A**ge (≥ 75 Years) (doubled), **D**iabetes Mellitus, **S**troke (doubled), **V**ascular Disease, **A**ge (65-74) Years, **S**ex **C**ategory (Female); COPD, chronic obstructive pulmonary disease; PCI; percutaneous coronary intervention.

* The income quartile was missing in 1.1%.

† Payer was missing in 3.4%.

‡ Urban location was defined as counties in metro areas with population > 50,000.

§ Total cost was missing in 4.2%.

‖ Excludes patients who died during initial hospitalization and those whose left atrial appendage closure procedure occurred in December.

¶ Excludes patients who died during initial hospitalization, whose procedure occurred in July−December, and who experienced a 30-day readmission.

** Adjusted *P*-values for each variable were computed from adjusting sampling design by discharge-level weights, cluster, and strata.

US and is produced by the Healthcare Cost and Utilization Project (HCUP).[5] The NRD contains deidentified unique patient numbers, allowing patients to be tracked across hospitals within a calendar year and facilitating assessment of readmissions. This database includes data from more than 20 geographically dispersed states and accounts for about 50% of the total US population and about 50% of all hospitalizations. The study population consisted of patients who underwent LAAC as a primary procedure between January 1, 2016 and December 31, 2018. The International Classification of Diseases, 10th revision (ICD-10) procedure code 02L73DK (occlusion of left atrial appendage, percutaneous approach) was used to identify eligible patients, who were then stratified based on the presence of previous ischemic cerebrovascular accident or TIA. Along with demographic information and hospital size and location, patient comorbidities were extracted so that comorbidity scores could be calculated. The thromboembolic risk was calculated with the $CHA_2DS_2$-VASc score[6,7] (**C**ongestive Heart Failure, **H**ypertension, **A**ge [≥ 75 Years] [doubled], **D**iabetes Mellitus, **S**troke [doubled], **V**ascular Disease, **A**ge [65-74] Years, **S**ex **c**ategory [Female]); and comorbidity burden was assessed using the Charlson Comorbidity Index (CCI)[8-10] and the Elixhauser Comorbidity Score (ECS).[11-13] Frailty status was assessed with the HFRS (**H**ospital **F**railty **R**isk **S**core).[14]

The primary outcome was the first unplanned readmission after LAAC. One dataset was used for readmissions that occurred within 0 to 30 days, and another dataset was used for those that occurred within 31 to 180 days. Patients who died during the initial hospitalization and those with elective readmissions were excluded. Patients in the 0 to 30 days

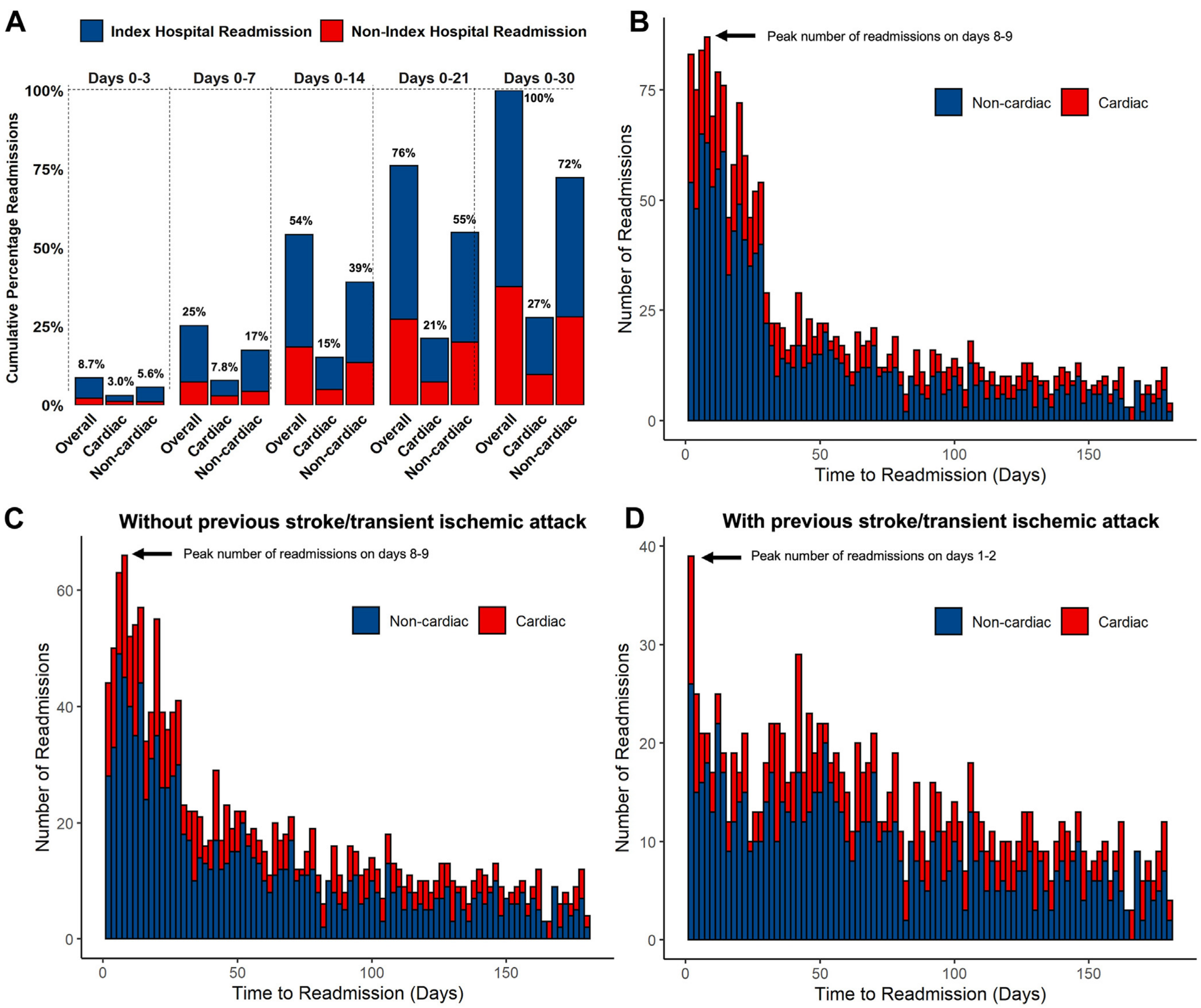


**Figure 1.** Graphical representation of time to cardiac and noncardiac readmissions after left atrial appendage closure. (**A**) Bar chart of 30-day cardiac and noncardiac readmission in the overall study population. (**B**) Histogram of 0-180—day cardiac and noncardiac readmissions stratified into 2-day intervals in the overall study population. (**C**) Histogram of 0-180—day cardiac and noncardiac readmissions among patients with previous stroke and/or transient ischemic attack stratified into 2-day intervals. (**D**) Histogram of 0-180—day cardiac and noncardiac readmissions among patients without previous stroke and/or transient ischemic attack, stratified into 2-day intervals.

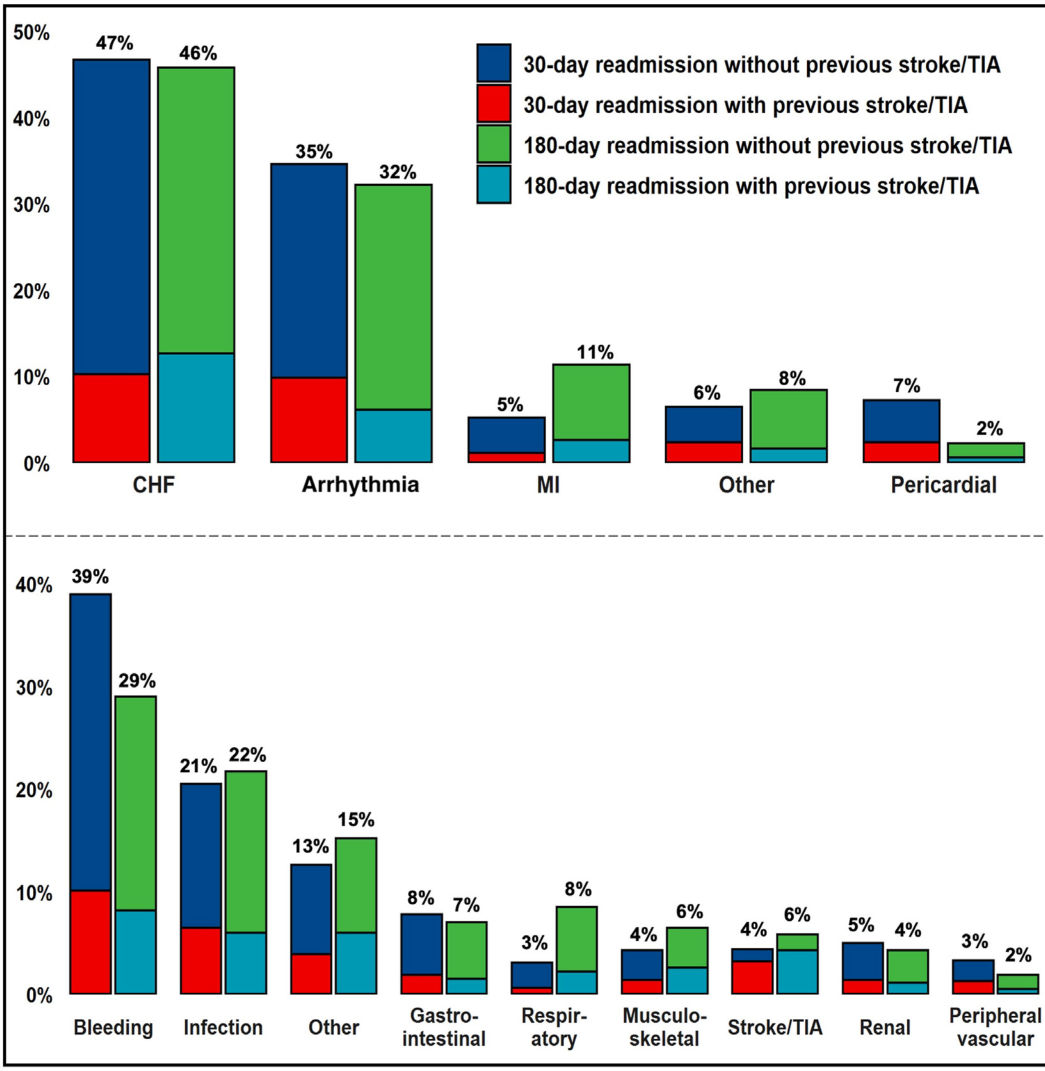


**Figure 2.** Causes of 30-day and 31-180—day cardiac (**top**) and noncardiac (**bottom**) readmission after left atrial appendage closure. Percentages represent the proportion of readmissions attributable to each cause. For cardiac readmissions, "other" causes were most commonly coded for valvular heart disease and postprocedural cardiac complications. For noncardiac readmissions, "other" causes were mostly related to malignancy, diabetes mellitus, syncope, delirium, and nonspecific neurologic abnormalities. CHF, congestive heart failure; MI, myocardial infarction; TIA, transient ischemic attack.

cohort were excluded if their index procedure occurred in December; likewise, patients whose procedure occurred from July to December were excluded from the 31 to 180 days cohort, as the NRD does not cross calendar years. The secondary outcome was causes of readmission that were divided into cardiac or noncardiac, and based on whether they occurred at the same or a different hospital as the LAAC procedure (index vs non-index hospital, respectively). Cardiac readmission causes included myocardial infarction, pericardial pathology, arrhythmias, and heart failure. In-hospital complications were defined as the composite of bleeding complications, cardiac complications, vascular complications, acute kidney injury, and postprocedural stroke or TIA. The ICD-10 codes that were used to identify comorbidities, in-hospital complications, and cardiac readmissions all were verified independently by 2 study authors (R.T.S. and R.B.) and are detailed in Supplemental Table S1.

Initial comparisons were performed between the baseline characteristics of patients with vs without previous ischemic stroke and/or TIA. Additional data were analyzed, stratifying patients by previous ischemic stroke and/or TIA status and comparing the characteristics of those with and without 30-day and 31-180—day readmission. Categorical variables were analyzed using the $\chi^2$ test and were reported as n (%); continuous variables were compared using the Kruskal-Wallis test, given their non normal distribution, and were reported as median (interquartile range).

Table cells with less than 11 discharge records are displayed as " < 11" because the exact count cannot be reported under the Healthcare Cost and Utilization Project data use agreement. Adjusted $P$ values for each variable were computed after multiple-comparison adjustment for survey sampling design by discharge-level weights, cluster, and strata, which were provided by the NRD. Multilevel multivariable regression analysis then

**Table 2. Characteristics of the study population with and without previous ischemic stroke and/or transient ischemic attack (TIA) and unplanned readmission within 30 days**

| | With previous stroke and/or TIA, n = 3274 | | | Without previous stroke and/ orTIA, n = 8419 | | | | |
|---|---|---|---|---|---|---|---|---|
| | 30-d readmission[§] | | | 30-d readmission[§] | | | | |
| Patient characteristics | No n = 2996 | Yes n = 278 | Adjusted *P*[‡] | No n = 7739 | Yes n = 680 | Adjusted *P*[‡] | Adjusted *P*, non-readmitted[‡] | Adjusted *P*, readmitted[‡] |
| Age, y | 77 (71−82) | 77 (71.25−82) | 0.56 | 77 (71−82) | 77 (71.75−82) | 0.16 | 0.87 | 0.89 |
| Sex, male | 1674 (56) | 150 (54) | 0.37 | 4585 (59) | 354 (52) | 0.37 | **0.004** | 0.71 |
| Median household income percentile | | | | | | | | |
| 0−25th | 587 (20) | 65 (23) | 0.38 | 1595 (21) | 151 (22) | 0.33 | 0.48 | 0.41 |
| 26−50th | 722 (24) | 71 (26) | | 1980 (26) | 168 (25) | | | |
| 51−75th | 875 (30) | 66 (24) | | 2132 (28) | 203 (30) | | | |
| 76−100th | 781 (26) | 75 (27) | | 1940 (25) | 151 (22) | | | |
| Medicare payer | 2634 (88) | 242 (88) | 0.85 | 6918 (90) | 605 (89) | 0.91 | 0.10 | 0.46 |
| Urban patient location[*] | 2597 (87) | 248 (89) | 0.21 | 6601 (85) | 601 (88) | **0.02** | 0.30 | 0.91 |
| Hospital teaching status | | | | | | | | |
| Urban nonteaching | 316 (11) | 27 (9.7) | 0.05 | 871 (11) | 74 (11) | 0.46 | **0.01** | 0.28 |
| Urban teaching | 2660 (89) | 246 (88) | | 6767 (87) | 601 (88) | | | |
| Rural | 20 (0.7) | < 11 (1.8) | | 101 (1.3) | < 11 (0.7) | | | |
| Hospital bed volume | | | | | | | | |
| Small | 169 (5.6) | 17 (6.1) | 0.27 | 483 (6.2) | 36 (5.3) | 0.17 | 0.23 | 0.32 |
| Medium | 648 (22) | 52 (19) | | 1734 (22) | 141 (21) | | | |
| Large | 2179 (73) | 209 (75) | | 5522 (71) | 503 (74) | | | |
| Index-hospital readmission | — | 166 (60) | — | — | 431 (63) | — | — | 0.16 |
| Comorbidities | | | | | | | | |
| Dyslipidemia | 1902 (63) | 181 (65) | 0.55 | 4574 (59) | 420 (62) | 0.08 | **< 0.001** | 0.34 |
| Renal disease | 592 (20) | 74 (27) | **0.004** | 1591 (21) | 232 (34) | **< 0.001** | 0.24 | 0.09 |
| CABG | 397 (13) | 45 (16) | 0.12 | 1084 (14) | 105 (15) | 0.35 | 0.28 | 0.61 |
| PCI | 459 (15) | 63 (23) | **0.002** | 1297 (17) | 123 (18) | 0.39 | 0.07 | 0.13 |
| Hypertension | 2611 (87) | 252 (91) | **0.05** | 6649 (86) | 610 (90) | **0.003** | 0.18 | 0.55 |
| Diabetes mellitus | 1045 (35) | 115 (41) | 0.06 | 2606 (34) | 274 (40) | **0.003** | 0.34 | 0.78 |
| Obesity | 436 (15) | 51 (18) | 0.15 | 1314 (17) | 123 (18) | 0.32 | **0.001** | 0.75 |
| Smoking | 1025 (34) | 112 (40) | **0.05** | 2536 (33) | 223 (33) | 0.91 | 0.08 | **0.03** |
| Congestive heart failure | 1001 (33) | 117 (42) | **0.01** | 2996 (39) | 342 (50) | **< 0.001** | **< 0.001** | **0.02** |
| Myocardial infarction | 377 (13) | 35 (13) | 0.98 | 884 (11) | 84 (12) | 0.27 | **0.05** | 0.98 |
| Peripheral vascular disease | 330 (11) | 36 (13) | 0.10 | 724 (9) | 78 (11) | **0.04** | **0.01** | 0.27 |
| Valvular heart disease | 622 (21) | 64 (23) | 0.37 | 1605 (21) | 179 (26) | **< 0.001** | 0.76 | 0.21 |
| COPD | 569 (19) | 70 (25) | **0.005** | 1629 (21) | 182 (27) | **< 0.001** | **0.04** | 0.95 |
| Liver disease | 70 (2.3) | 10 (3.6) | 0.36 | 216 (3) | 33 (5) | 0.003 | 0.20 | 0.23 |
| Dementia | 114 (3.8) | 15 (5.4) | 0.16 | 194 (3) | 22 (3) | 0.15 | **< 0.001** | 0.09 |
| Hypothyroidism | 461 (15) | 47 (17) | 0.43 | 1174 (15) | 114 (17) | 0.28 | 0.91 | 0.90 |
| Coagulopathy | 103 (3.4) | < 11 (2.2) | 0.64 | 277 (4) | 40 (6) | 0.01 | 0.59 | 0.11 |
| Cancer | 73 (2.4) | 12 (4.3) | 0.14 | 192 (2) | 21 (3) | 0.44 | 0.79 | 0.49 |
| Anemia | 183 (6.1) | 31 (11) | **0.001** | 526 (7) | 107 (16) | **< 0.001** | 0.18 | 0.08 |
| Charlson comorbidity index | 2 (1−4) | 3 (2−5) | **< 0.001** | 1 (0−3) | 2 (1−4) | **< 0.001** | **< 0.001** | **< 0.001** |
| Elixhauser comorbidity score | 8 (5−13) | 11 (5−15) | **< 0.001** | 8 (5−13) | 11 (5−16) | **< 0.001** | 0.48 | 0.83 |
| $CHA_2DS_2$-VASc score | 6 (5−7) | 6 (5−7) | **0.002** | 4 (3−4) | 4 (3−5) | **< 0.001** | **< 0.001** | **< 0.001** |
| Hospital frailty risk score | 2 (0.5−4.2) | 2.9 (1.5−5.5) | **< 0.001** | 1.5 (0−2.9) | 2 (1.0−3.7) | **< 0.001** | **< 0.001** | **< 0.001** |
| In-hospital adverse events, index admission | | | | | | | | |
| Total major adverse events | 140 (4.7) | 21 (7.6) | 0.08 | 349 (4.5) | 79 (12) | **< 0.001** | 0.90 | 0.07 |
| Cardiac complications | 54 (1.8) | < 11 (2.2) | 0.60 | 147 (1.9) | 31 (4.6) | **< 0.001** | 0.64 | 0.19 |
| Bleeding complications | 19 (0.6) | < 11 (1.1) | 0.66 | 44 (0.6) | < 11 (1.3) | **0.04** | 0.76 | 0.52 |
| Vascular complications | 14 (0.5) | < 11 (0) | 0.25 | 19 (0.2) | < 11 (1.0) | **0.002** | 0.18 | 0.09 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Stroke and/or TIA | 18 (0.6) | < 11 (1.1) | 0.57 | 19 (0.2) | < 11 (0.9) | **0.03** | **0.02** | 0.89 |
| Acute kidney injury | 61 (2.0) | 11 (4.0) | **0.04** | 155 (2) | 41 (6) | **< 0.001** | 0.94 | 0.28 |
| Length of stay, index admission. d | 1 (1−1) | 1 (1−1) | **0.01** | 1 (1−1) | 1 (1−1) | **< 0.001** | **0.02** | 0.35 |
| ≤ 1 | 2627 (88) | 222 (80) | **0.01** | 6920 (89) | 528 (78) | **< 0.001** | **0.02** | 0.23 |
| > 1 | 369 (12) | 56 (20) | | 819 (11) | 152 (22) | | | |
| Total index cost (USD$)† | 25,332 (18,919−30,752) | 25,316 (19,249−30365) | 0.79 | 25,201 (18,789−30,763) | 24,552 (18,982−30,886) | 0.75 | 0.48 | 0.52 |

Values are expressed as median (interquartile range) or count (%), unless otherwise indicated. Boldface indicates statistical significance. Some percentages may not add up to 100%, owing to rounding. Exact counts for variables with < 11 patients are not detailed, per the Healthcare Cost and Utilization Project data use agreement.

CABG. coronary artery bypass grafting; $CHA_2DS_2$-VASc, **C**ongestive Heart Failure, **H**ypertension, **A**ge (≥ 75 Years) (doubled), **D**iabetes Mellitus, **S**troke (doubled), **V**ascular Disease, **A**ge (65-74) Years, **S**ex **C**ategory (Female); COPD, chronic obstructive pulmonary disease; PCI, percutaneous coronary intervention.

* Urban location was defined as counties in metro areas with population > 50,000.

† Total cost was missing in 0.42%.

‡ Adjusted *P*-values were computed from adjusting sampling design by discharge-level weights, cluster, and strata.

§ Excludes patients who died during initial hospitalization and those whose left atrial appendage closure procedure occurred in December.

was used to determine the factors that were independently associated with readmissions within 30 days and within 31 to 180 days among patients with previous ischemic stroke and/or TIA. Further regression models were used to identify factors associated with cardiac and noncardiac readmission. The variables entered in the models were those clinically relevant variables that were selected a priori and based on the univariate results, with a *P* value of < 0.10 (non parsimonious model). The models were further adjusted by sex, elective admission, and neighbourhood income quartiles. To further analyze readmission rates, a histogram based on days-to-readmission was created and further divided into cardiac vs noncardiac causes. The results of the models are presented as odds ratio (OR) with 95% confidence interval (CI). All *P* values are 2-sided, with a significance threshold of < 0.05. Statistical analyses were performed using R version 3.6.3 (R Foundation, Vienna, Austria).[15]

## Results

### Study population

A total of 12,901 unweighted hospitalizations for LAAC were identified; of these, 3752 (28%) had a previous history of ischemic stroke and/ or TIA. Those with a history of ischemic stroke and/or TIA were more likely to be female (44% vs 41%, $P = 0.002$) and showed a higher burden of comorbidities, as assessed by a higher CCI (2 [interquartile range: 1-4] vs 1 [interquartile range: 1-3], $P < 0.001$), and a higher thromboembolic risk, as assessed by a higher $CHA_2DS_2$-VASc score (6 [interquartile range: 5-7] vs 4 [interquartile range: 3-4], $P < 0.001$).

The rate of major in-hospital adverse events was 5.2% and was similar between previous ischemic stroke and/or TIA and non−previous ischemic stroke and/or TIA groups (5.0% vs 5.3%, respectively, $P = 0.41$). Notably, the only individual in-hospital complication that differed was the occurrence of new stroke and/or TIA, which was more frequent in the previous ischemic stroke and/or TIA group (0.7% vs 0.3%, $P = 0.01$). Detailed data on baseline characteristics and in-hospital outcomes are shown in Table 1.

### Unplanned readmission

A total of 22 patients (0.2%) died during the index−LAAC procedure admission and thus were excluded, along with 1184 (9.2%) who had their LAAC procedure in December, leaving 11,693 individuals for the 30-day readmission analysis. For the 31-to-180−day readmission cohort, 5960 patients (46%) whose procedure occurred from July to December were excluded, as were 469 patients (3.6%) who had a readmission within 30 days, leaving 5264 eligible patients for the 31-to-180−day readmission analysis.

Unplanned readmission occurred in 958 eligible patients (8.2%) at 30 days, and 959 patients (18%) had a readmission in the period between 31 and 180 days. For both periods, the readmission rate did not differ significantly among those with vs without previous ischemic stroke and/or TIA ($P = 0.26$ for 30-day, and $P = 0.17$ for 31-180−day; Table 1). Figure 1A stratifies 30-day unplanned readmission by periods, cardiac vs noncardiac diagnosis, and admission to the index vs a non-

**Table 3. Characteristics of the study population with and without previous stroke and/or TIA and unplanned readmission within 31-180 days**

| Patient characteristics | With previous stroke and/or TIA, n = 1415 | | | Without previous Stroke and/or TIA, n = 3827 | | | | |
|---|---|---|---|---|---|---|---|---|
| | Readmission within 31-180 d[§] | | | Readmission within 31-180 d[§] | | | | |
| | No n = 1111 | Yes n = 304 | Adjusted $P$[‡] | No n = 3059 | Yes n = 768 | Adjusted $P$[‡] | Adjusted $P$, non-readmitted[‡] | Adjusted $P$, readmitted[‡] |
| Age, y | 76 (71–82) | 78 (71–83.5) | 0.08 | 76 (71–82) | 76 (71–83) | 0.18 | 0.59 | 0.48 |
| Sex, male | 621 (56) | 154 (51) | 0.92 | 1917 (63) | 372 (48) | 0.92 | **0.001** | 0.89 |
| Median household income percentile | | | | | | | | |
| 0–25th | 218 (19) | 56 (20) | 0.32 | 637 (20) | 166 (25) | 0.13 | 0.18 | 0.64 |
| 26–50th | 257 (23) | 80 (28) | | 791 (25) | 186 (28) | | | |
| 51–75th | 349 (31) | 71 (25) | | 862 (28) | 158 (24) | | | |
| 76–100th | 299 (27) | 74 (26) | | 838 (27) | 159 (24) | | | |
| Medicare payer | 991 (87) | 259 (92) | **0.03** | 2833 (90) | 618 (92) | 0.08 | 0.07 | 0.92 |
| Urban patient location* | 992 (87) | 252 (89) | 0.26 | 2687 (85) | 595 (88) | 0.01 | 0.22 | 0.81 |
| Hospital teaching status | | | | | | | | |
| Urban nonteaching | 107 (9.4) | 35 (12) | **0.01** | 347 (11) | 93 (14) | 0.26 | 0.10 | **0.01** |
| Urban teaching | 1023 (90) | 248 (88) | | 2766 (87) | 575 (85) | | | |
| Rural | < 11 (0.9) | < 11 (0) | | 52 (1.6) | < 11 (1.2) | | | |
| Hospital bed volume | | | | | | | | |
| Small | 66 (5.8) | 17 (6) | 0.68 | 223 (7) | 38 (5.6) | 0.06 | 0.16 | 0.59 |
| Medium | 231 (20) | 62 (22) | | 687 (22) | 162 (24) | | | |
| Large | 843 (74) | 204 (72) | | 2255 (71) | 476 (70) | | | |
| Index-hospital readmission | — | 139 (49) | — | — | 390 (58) | — | — | **0.002** |
| Comorbidities | | | | | | | | |
| Dyslipidemia | 713 (63) | 195 (69) | 0.23 | 1832 (58) | 412 (61) | 0.16 | **0.01** | 0.11 |
| Renal disease | 205 (18) | 63 (22) | 0.12 | 573 (18) | 206 (30) | **< 0.001** | 0.84 | 0.02 |
| CABG | 156 (14) | 36 (13) | 0.67 | 410 (13) | 109 (16) | 0.07 | 0.64 | 0.23 |
| PCI | 167 (15) | 55 (19) | 0.06 | 559 (18) | 110 (16) | 0.63 | **0.005** | 0.56 |
| Hypertension | 997 (87) | 257 (91) | 0.21 | 2688 (85) | 591 (87) | 0.29 | 0.04 | 0.17 |
| Diabetes mellitus | 375 (33) | 116 (41) | **0.02** | 1029 (33) | 274 (41) | **< 0.001** | 0.80 | 0.86 |
| Obesity | 163 (14) | 35 (12) | 0.48 | 505 (16) | 116 (17) | 0.76 | 0.17 | 0.13 |
| Smoking | 396 (35) | 106 (37) | 0.50 | 1088 (34) | 237 (35) | 0.68 | 0.38 | 0.42 |
| Congestive heart failure | 358 (31) | 109 (39) | 0.09 | 1108 (35) | 318 (47) | **< 0.001** | 0.08 | **0.01** |
| Myocardial infarction | 128 (11) | 36 (13) | 0.80 | 361 (11) | 80 (12) | 0.72 | 0.82 | 0.89 |
| Peripheral vascular disease | 122 (11) | 39 (14) | 0.31 | 289 (9.5) | 71 (11) | 0.47 | 0.29 | 0.30 |
| Valvular heart disease | 216 (19) | 68 (24) | 0.11 | 667 (21) | 159 (24) | 0.19 | 0.14 | 0.92 |
| COPD | 191 (17) | 70 (25) | **< 0.001** | 608 (19) | 200 (30) | **< 0.001** | 0.06 | 0.56 |
| Liver disease | 24 (2.1) | < 11 (3.2) | 0.27 | 72 (2.4) | 23 (3.0) | 0.17 | 0.68 | 0.96 |
| Dementia | 41 (3.6) | < 11 (2.8) | 0.99 | 72 (2.4) | 14 (1.8) | 0.54 | 0.02 | 0.15 |
| Hypothyroidism | 156 (14) | 55 (19) | **0.04** | 483 (15) | 117 (17) | 0.06 | 0.28 | 0.95 |
| Coagulopathy | 31 (2.7) | 14 (4.9) | **0.03** | 106 (3.5) | 31 (4.0) | 0.25 | 0.12 | 0.68 |
| Cancer | 30 (2.6) | 10 (3.5) | 0.41 | 85 (2.8) | 18 (2.3) | 0.91 | 0.99 | 0.49 |
| Anemia | 60 (5.3) | 37 (13) | **< 0.001** | 209 (6.8) | 76 (11) | **< 0.001** | 0.14 | 0.42 |
| Charlson Comorbidity Index | 2 (1–4) | 3 (2–4) | **< 0.001** | 1 (0–3) | 2 (1–4) | **< 0.001** | **< 0.001** | **< 0.001** |
| Elixhauser Comorbidity Score | 8 (5–12) | 10 (5–14.5) | **0.01** | 8 (5–12) | 11 (5–15) | **< 0.001** | 0.22 | 0.24 |
| $CHA_2DS_2$-VASc score | 6 (5–6) | 6 (5–7) | 0.05 | 4 (3–4) | 4 (3–5) | **< 0.001** | **< 0.001** | **< 0.001** |
| Hospital frailty risk score | 1.8 (0.2–3.9) | 2.5 (1.4–4.7) | **0.005** | 1.5 (0–2.9) | 1.9 (0.8–3.7) | **< 0.001** | **< 0.001** | **0.003** |
| In-hospital adverse events, index admission | | | | | | | | |
| Total major adverse events | 53 (4.6) | 20 (7.1) | 0.12 | 118 (3.7) | 32 (4.7) | 0.65 | 0.41 | 0.10 |
| Cardiac complications | 19 (1.7) | < 11 (3.2) | 0.14 | 55 (1.7) | < 11 (1.3) | 0.18 | 0.69 | 0.03 |
| Bleeding complications | < 11 (0.8) | < 11 (0.7) | 0.98 | 12 (0.4) | < 11 (0.7) | 0.44 | 0.33 | 0.97 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Vascular complications | < 11 (0.4) | < 11 (1.1) | 0.25 | < 11 (0.1) | < 11 (0.4) | **0.03** | **0.02** | 0.36 |
| Stroke and/or TIA | < 11 (0.4) | < 11 (1.1) | 0.26 | 12 (0.4) | < 11 (0) | 0.13 | 0.84 | **0.01** |
| Acute kidney injury | 23 (2) | 10 (3.5) | 0.13 | 44 (1.4) | 20 (3) | 0.01 | 0.16 | 0.60 |
| Length of stay, index admission, d | 1 (1−1) | 1 (1−1) | **0.03** | 1 (1−1) | 1 S | **< 0.001** | 0.10 | 0.95 |
| ≤ 1 | 1003 (88) | 229 (81) | **0.003** | 2859 (90) | 564 (83) | **< 0.001** | 0.11 | 0.67 |
| > 1 | 137 (12) | 54 (19) | | 306 (9.7) | 112 (17) | | | |
| Total index cost (USD$)[†] | 25,061 (19,054−30,531) | 25,153 (19,863−30,927) | 0.18 | 24,804 (18,767−30,055) | 25,339 (18,952−30,882) | 0.26 | 0.37 | 0.32 |

Values are expressed as median (interquartile range) or count (%), unless otherwise indicated. Boldface indicates statistical significance. Some percentages may not add up to 100%, owing to rounding. Exact counts for variables with < 11 patients are not detailed, per the Healthcare Cost and Utilization Project data use agreement.

CABG, coronary artery bypass surgery; $CHA_2DS_2$-VASc, **C**ongestive Heart Failure, **H**ypertension, **A**ge (≥ 75 Years) (doubled), **D**iabetes Mellitus, **S**troke (doubled), **V**ascular Disease, **A**ge (65-74) Years, **S**ex **C**ategory (Female); COPD, chronic obstructive pulmonary disease; PCI, percutaneous coronary intervention.

* Urban location was defined as counties in metro areas with population > 50,000.

† Total cost was missing in 0.31%.

‡ Adjusted *P*-values were computed from adjusting sampling design by discharge-level weights, cluster, and strata.

§ Excludes patients who died during initial hospitalization, whose procedure occurred in July−December, and who experienced a 30-day readmission.

index hospital. Most patients were readmitted to index hospitals. Figure 1B displays the histogram of days to the first unplanned readmission, with the peak number of readmissions occurring on days 8 and 9. Notably, this matches the peak of readmissions for individuals without previous ischemic stroke and/or TIA (Figure 1C), whereas the peak of readmissions was 1-2 days among those with previous ischemic stroke and/or TIA (Fig. 1D).

The frequencies for the most common readmission diagnoses for each readmission within 30 days and within 31 to 180 days, stratified by cardiac and noncardiac causes, are displayed in Figure 2. Cardiac causes represented 28% of readmission within 30 days, and 32% of those within 31 to 180 days, with heart failure representing almost half of cardiac readmissions for both timeframes; myocardial infarction was twice as likely to be a cause of readmission at 31 to 180 days, compared with those within 30 days (11% vs 5%). Among noncardiac causes, bleeding complications were the most frequent cause of readmission in both timeframes (39% and 29%, respectively). New stroke and/or TIA was the cause of readmission in 0.6% of the patients (68 of 11,693) in the 30-day cohort and 1.2% (63 of 5264) in the 31-180−day cohort, accounting for 4% and 6% of the total number of noncardiac readmissions at 30 days and at 31 to 180 days, respectively. This finding translates into a significantly higher proportion of total readmissions among individuals with a prior history of ischemic stroke and/or TIA (3.2% vs 1.2% of readmissions at 30 days, $P = 0.01$; and 4.3% vs 1.5% of readmissions at 31—180 days, $P < 0.003$; Fig. 2).

### Factors associated with readmission within 30 days and within 180 days

Women were more likely to be readmitted within both 30 days and 31-180 days (Tables 2 and 3). Among patients with and without previous ischemic stroke and/or TIA, those with 30-day readmissions had a higher prevalence of comorbidities, leading to higher CCI and ECS values ($P < 0.001$, for both), as well as a higher thromboembolic risk profile, as assessed by $CHA_2DS_2$-VASc score ($P < 0.01$), and a higher level of frailty, as assessed by the HFRS ($P < 0.01$; Table 2).

The overall rate of post-LAAC in-hospital major adverse events was not significantly different ($P = 0.08$) among those with previous ischemic stroke and/or TIA vs those who subsequently had a 30-day readmission; however, the occurrence of acute kidney injury during readmission (2% vs 4%, $P = 0.04$) was the only component that was higher among individuals who were readmitted within 30 days. Substantial differences were encountered among individuals without a prior history of ischemic stroke and/or TIA in terms of overall in-hospital complication rates ($P < 0.001$), and hence, in each of the individual components of the composite endpoint. Prolonged length of stay (LOS; > 1 day) during the index hospital admission was observed in both groups that were subsequently readmitted at 30 days (Table 2).

Similarly, patients with and without previous ischemic stroke and/or TIA who were readmitted between 31 and 180 days had a higher prevalence of comorbidities, leading to higher CCI and ECS ($P < 0.01$ for both) as well as HFRS ($P < 0.01$). No difference ($P = 0.05$) occurred in the $CHA_2DS_2$-VASc score among individuals with previous

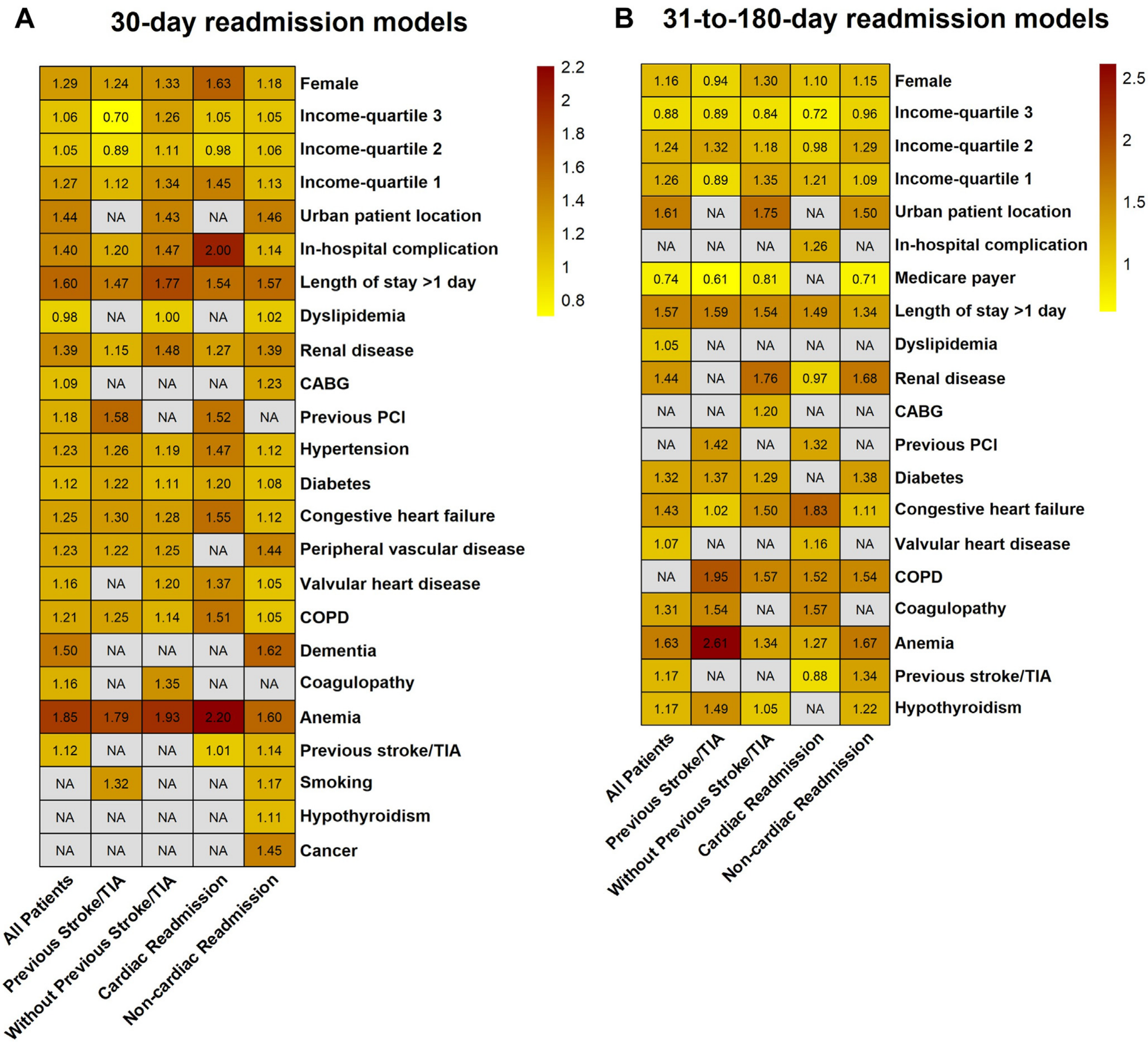


**Figure 3.** Heatmap of odds ratios of multivariable models predicting readmission. Graphical representation of the odds ratios of each clinical factor for the models, with darker colours representing higher odds, irrespective of their *P*-value. (**A**) Odds ratios of 30-day readmission models. (**B**) Odds ratios of 31-180—day readmission models. Income-quartile 4 (75th-100th percentile) was used as the reference group for analysis. Cells with NA (not applicable) indicate that the comorbidity was not included in the model. CABG, coronary artery bypass grafting; COPD, chronic obstructive pulmonary disease; PCI, percutaneous coronary intervention; TIA, transient ischemic attack.

ischemic stroke and/or TIA who subsequently had readmissions at 31 to 180 days, whereas the CHA$_2$DS$_2$-VASc score and the HFRS were significantly higher ($P < 0.01$, for both) among those without previous ischemic stroke and/or TIA who were readmitted. Prolonged LOS (> 1 day) during the index hospital admission also was observed in both groups that were subsequently readmitted at 31-180 days (Table 3).

The multivariable regression analyses yielded further insights into factors that were independently associated with readmission at 30 days and 31-180 days (Fig. 3; Supplemental Table S2). Among patients with previous ischemic stroke and/or TIA, female sex (OR: 1.24, 95% CI: 1.01-1.52, $P = 0.04$), prolonged LOS during index admission (OR: 1.44, 95% CI: 1.06-1.95, $P = 0.02$), previous percutaneous coronary intervention (OR: 1.58, 95% CI: 1.23-2.04, $P < 0.001$), smoking (OR: 1.32, 95% CI: 1.07-1.63, $P = 0.01$), heart failure (OR: 1.30, 95% CI: 1.05-1.61, $P = 0.02$), and anemia (OR: 1.78, 95% CI: 1.27-2.51, $P < 0.001$) were the comorbidities that had the largest impact on risk of 30-day readmission.

Among patients without previous ischemic stroke and/or TIA, female sex (OR: 1.33, 95% CI: 1.17-1.50, $P < 0.001$), low median neighbourhood income quartile (OR: 1.34, 95% CI: 1.09-1.64, $P = 0.01$ for quartile 1 vs quartile 4), urban location (OR: 1.43, 95% CI: 1.16-1.75, $P < 0.001$), index

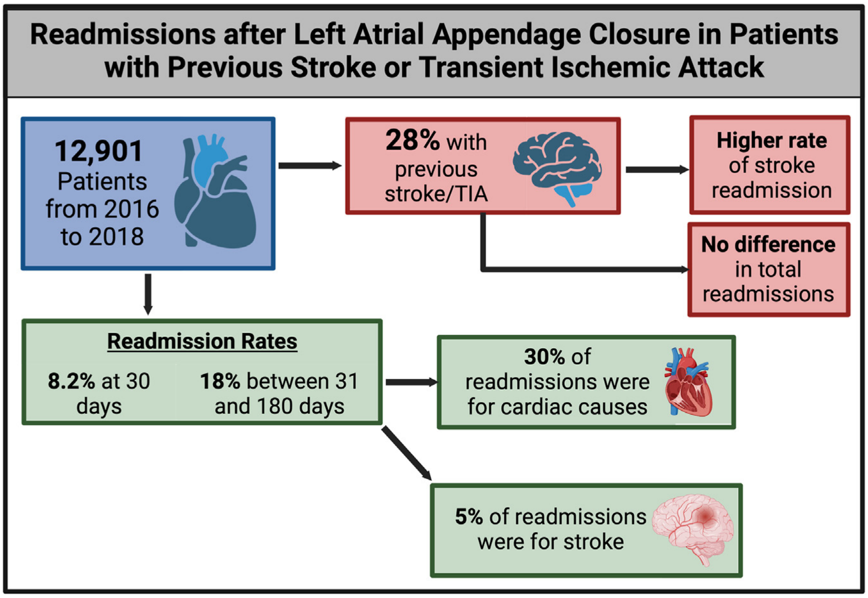


**Figure 4.** Readmission after left atrial appendage closure in patients with previous ischemic stroke or transient ischemic attack (TIA).

in-hospital complication (OR: 1.47, 95% CI: 1.17-1.85, $P = 0.001$), prolonged LOS during index admission (OR: 1.76, 95% CI: 1.48-2.11, $P < 0.001$), chronic kidney disease (OR: 1.48, 95% CI: 1.28-1.71, $P < 0.001$), heart failure (OR: 1.28, 95% CI: 1.12-1.45, $P < 0.001$), coagulopathy (OR: 1.35, 95% CI: 1.02-1.79, $P = 0.03$), and anemia (OR: 1.93, 95% CI: 1.61-2.32, $P < 0.001$) were the factors that were independently associated with 30-day readmission.

Prolonged LOS during index admission (OR: 1.59, 95% CI: 1.14-2.22, $P = 0.01$), previous percutaneous coronary intervention (OR: 1.42, 95% CI: 1.04-1.95, $P = 0.03$), diabetes (OR: 1.37, 95% CI: 1.08-1.75, $P = 0.01$), chronic obstructive pulmonary disease (COPD; OR: 1.95, 95% CI: 1.47-2.60, $P < 0.001$), hypothyroidism (OR: 1.49, 95% CI: 1.08-2.07, $P = 0.02$), and anemia (OR: 2.61, 95% CI: 1.74-3.91, $P < 0.001$) were the comorbidities that had the largest impact on risk of readmission within 31-180 days among patients with previous ischemic stroke and/or TIA.

Female sex (OR: 1.30, 95% CI: 1.12-1.50, $P < 0.001$), low median neighbourhood income quartile (OR: 1.35, 95% CI: 1.07-1.71, $P = 0.01$ for quartile 1 vs quartile 4), urban location (OR: 1.75, 95% CI: 1.38-2.22, $P < 0.001$), prolonged LOS during index admission (OR: 1.54, 95% CI: 1.24-1.91, $P < 0.001$), renal disease (OR: 1.76, 95% CI: 1.49-2.09, $P < 0.001$), diabetes (OR: 1.29, 95% CI: 1.12-1.50, $P < 0.001$), heart failure (OR: 1.50, 95% CI: 1.29-1.73, $P < 0.001$), COPD (OR: 1.57, 95% CI: 1.33-1.83, $P < 0.001$), and anemia (OR: 1.34, 95% CI: 1.05-1.70, $P = 0.02$) were the factors that were independently associated with 31-180−day readmission among patients without previous ischemic stroke and/or TIA.

Figure 3 and Supplemental Table S3 provide insights into the factors associated with 30-day and 31-to-180−day readmission, further split by cardiac vs noncardiac causes of readmission. Notably, a prior history of ischemic stroke and/or TIA was among the factors that were strongly associated with noncardiac causes of readmission.

### Post hoc analysis

To explore any potential seasonal effect on baseline demographics and clinical characteristics that could lead to a difference in outcomes, we performed a post hoc exploratory analysis stratifying the population who underwent LAAC procedures from January to June and from July to November. Reassuringly, no major differences were present in baseline characteristics, postprocedural outcomes, or 30-day readmission rates, which limits the likelihood that a seasonal effect influenced the outcome of interest (Supplemental Table S4).

## Discussion

In this large analysis of 12,901 discharges for LAAC between 2016 and 2018, 8.2% and 18% of patients had an unplanned readmission within 30 days and within 31-180 days, respectively. The rates of in-hospital complications following LAAC and readmission within 30 days and within 31-180 days did not significantly differ among patients with vs without a prior history of ischemic stroke and/or TIA. Cardiac readmissions represented about 30% of total readmissions, and congestive failure, bleeding, and infections were the most common readmission diagnoses in the overall cohort. An important point to note is that new stroke and/or TIA accounted for 4% and 6% of the total number of noncardiac readmissions at 30 days and 31-180 days, respectively, and the incidence was significantly higher among those with a prior history of ischemic stroke and/or TIA. Female sex as well as index hospitalization LOS > 1 day were among the strongest factors independently associated with 30-day readmission. Prior history of ischemic stroke and/or TIA was among the strongest factors associated with noncardiac causes of readmission (Fig. 4).

## Readmission after LAAC

The observed 8.2% readmission rate at 30 days is slightly lower than that reported in previous studies, in which the overall 30-day readmission rate was 9.4%.[16,17] Moreover, the rates were lower than those reported for other catheter-based cardiac procedures, including catheter ablation for atrial fibrillation (11%),[18,19] transcatheter aortic valve implantation (11%),[20] and transcatheter edge-to-edge mitral valve repair (14%-16%).[21,22]

One of the novel aspects of this study is the analysis of post-LAAC outcomes[23] in patients with previous ischemic stroke and/or TIA. Unsurprisingly, the rate of in-hospital stroke and/or TIA after LAAC was higher in patients with previous ischemic stroke and/or TIA. However, a reassuring finding is that the total in-hospital complications, and the readmission rates at 30 days and 31-180 days were similar among those with vs without prior history of ischemic stroke and/or TIA. This finding is important given that those undergoing LAAC with previous ischemic stroke and/or TIA had a higher $CHA_2DS_2$-VASc score and a higher burden of comorbidities.

Previous research has shown that the benefit of anticoagulation with warfarin in preventing stroke in people with atrial fibrillation is greatest in those who have a history of previous ischemic stroke or TIA.[24] Meta-analysis of data from the PROTECT AF (WATCHMAN Left Atrial Appendage System for Embolic **Protect**ion in Patients With **A**trial **F**ibrillation) and PREVAIL (**P**rospective **R**andomized **Eva**luation of the WATCHMAN LAA Closure Device **i**n Patients With Atrial Fibrillation vs **L**ong-Term Warfarin Therapy) trials demonstrated that LAAC was noninferior to warfarin at preventing stroke, systemic embolism, and cardiovascular death. Notably, a consistent treatment effect was observed in patients with prior stroke or TIA who were enrolled in the trials for secondary prevention of cerebrovascular accidents.[25] LAAC was also noninferior to new oral anticoagulants for preventing major cardiovascular, neurologic, and bleeding events.[26] Therefore, given that this subgroup of patients likely derives more benefit from LAAC, and has similar rates of adverse events, a reasonable suggestion is that LAAC should be considered even more strongly in this subgroup of patients when contraindication to anticoagulation is present.

## Clinical factors

A second important finding of this research was identification of the clinical factors that were independently associated with cardiac and noncardiac readmission among patients with previous ischemic stroke and/or TIA. In all patient subgroups, female sex was independently associated with readmission within 30 days and within 31-180 days. For cardiac readmissions specifically, women had a 1.6-fold higher rate of readmission at 30 days, although this was not observed for the 31-180−days timeframe. The clinical trial data for LAAC demonstrated equal efficacy in men and women.[25] Nevertheless, given that women historically are underrepresented in clinical trials,[7] confirmation of this finding and an understanding of its potential causes are areas for future research.

Beyond sex differences, index hospitalization LOS > 1 day was significantly associated with readmission in both groups. Among previous ischemic stroke and/or TIA patients, 20% of those with a subsequent 30-day readmission had an initial LOS > 1 day, compared with 12% of those who were not readmitted. In this regard, prolonged LOS has been found to predict readmission after transcatheter aortic valve implantation[27] and after atrial fibrillation catheter ablation.[18] For cardiac 30-day readmission specifically, significant associations were found for those presenting with preprocedural anemia, chronic kidney disease, and heart failure, and those who experienced post-LAAC in-hospital major adverse events. For noncardiac readmission, chronic comorbid conditions, such as renal disease, diabetes, COPD, and notably, previous ischemic stroke and/or TIA, were the factors most associated with longer-term (at 31-180 days) readmission. The presence of anemia, a surrogate marker closely linked to bleeding risk, emerged as another significant predictor of readmission in patients with atrial fibrillation.

## Limitations

Given that this study was an observational and retrospective analysis, it has several limitations. The accuracy of the findings relies on the ICD-10 coding in the NRD, and coding errors during data entry could influence study results. However, the use of ICD, 9th revision (ICD-9)_ and ICD-10 codes has been shown to be accurate for the diagnosis of stroke and TIA, and no quantitative improvements were observed with the switch from the ICD-9 to the ICD-10 system.[28] An important point to note is that these codes apply to the in-hospital setting only (data gathered at hospital discharge); therefore, those individuals with minor symptoms or TIA who did not seek medical attention might not be captured.[28] Furthermore, a lack of granularity prevents determination of whether individuals readmitted with stroke and/or TIA events underwent imaging testing. Potential confounders, such as medication and anticoagulant use, and procedure operator experience and/or volume, were not captured.

Ideally, calculation of the HAS-BLED score (**H**ypertension, **A**bnormal Renal/Liver Function, **S**troke, **B**leeding History or Predisposition, **L**abile International Normalized Ratio, **E**lderly, **D**rugs/Alcohol Concomitantly) would have allowed the calculation of periprocedural bleeding risk, but unfortunately, the NRD does not code such information. Nonetheless, the impact this score has on readmission following LAAC is yet to be determined. Additionally, specific factors contributing to a patient's risk of stroke and/or TIA, including cardiomyopathy, ventricular dyskinesia, ventricular aneurysm, and thrombophilia such as hyperhomocysteinemia[29,30] are other causes of cardioembolic stroke aside from atrial fibrillation, and these were unable to be identified given the limitations of the NRD. Finally, the databases do not cross calendar years, thereby precluding longitudinal follow-up that ultimately has an impact on the selected study population. In addition, survival analyses using the NRD are limited by the unknown vital status of patients during follow-up. Some patients, for instance, may have died (outside of the hospital), and we could not confirm such deaths, as only deaths that occurred during an episode of readmission are trackable.

# Conclusion

In this nationwide, observational analysis of patients with and without previous ischemic stroke and/or TIA who underwent LAAC, we found no significant difference in overall in-hospital complications, or in 30-day or 31-to-180−day readmission rates. Heart failure, bleeding, and infection were the most common readmission diagnoses in the overall cohort. Female sex and index hospitalization LOS > 1 day were among the strongest factors that were independently associated with 30-day readmission.

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## Data Availability

All data relevant to the study are included in the article or are provided in the Supplementary Material.

## Ethics Statement

The Western University Health Science Research Ethics Board exempted the need for consent as well as ethics committee or institutional review board approval for this study because all data were de-identified.

## Patient Consent

All data used for this research was derived from the National Readmission Database, a publicly available and de-identified administrative database; therefore, the IRB did not require consent from the patients.

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## Disclosures

The authors have no conflicts of interest to disclose.

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## Supplementary Material

To access the supplementary material accompanying this article, visit *CJC Open* at https://www.cjcopen.ca/ and at https://doi.org/10.1016/j.cjco.2023.09.009.