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Feasibility of using real-world data in the evaluation of cardiac ablation catheters: a test-case of the National Evaluation System for Health Technology Coordinating Center

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ABSTRACT

Objectives To determine the feasibility of using real-world data to assess the safety and effectiveness of two cardiac ablation catheters for the treatment of persistent atrial fibrillation and ischaemic ventricular tachycardia.

Design Retrospective cohort.

Setting Three health systems in the USA.

Participants Patients receiving ablation with the two ablation catheters of interest at any of the three health systems.

Main outcome measures Feasibility of identifying the medical devices and participant populations of interest as well as the duration of follow-up and positive predictive values (PPVs) for serious safety (ischaemic stroke, acute heart failure and cardiac tamponade) and effectiveness (arrhythmia-related hospitalisation) clinical outcomes of interest compared with manual chart validation by clinicians.

Results Overall, the catheter of interest for treatment of persistent atrial fibrillation was used for 4280 ablations and the catheter of interest for ischaemic ventricular tachycardia was used 1516 times across the data available within the three health systems. The duration of patient follow-up in the three health systems ranged from 91% to 97% at ≥7 days, 89% to 96% at ≥30 days, 77% to 90% at ≥6 months and 66% to 84% at ≥1 year. PPVs were 63.4% for ischaemic stroke, 96.4% for acute heart failure, 100% at one health system for cardiac tamponade and 55.7% for arrhythmia-related hospitalisation.

Conclusions It is feasible to use real-world health system data to evaluate the safety and effectiveness of cardiac ablation catheters, though evaluations must consider the implications of variation in follow-up and endpoint ascertainment among health systems.

Key messages

What is already known about this subject?

- Recent legislation and policy have increased the importance of using real-world evidence to support regulatory decision-making for medical devices.
- Little is known about the ability to use health system data to conduct research about medical device safety and effectiveness.

What are the new findings?

- We used a decentralised model of research to conduct a retrospective cohort analysis at three health systems, identifying cardiac ablation catheters of interest and patients in whom they were used for specific indications.
- We found a distribution of follow-up duration between the health systems (ranging from 66% to 84% at ≥1 year), indicating some variation in long-term follow-up of ablation patients; patients were identified in whom follow-up was generally adequate to support both periprocedural and longer term clinical outcome ascertainment.
- We found a distribution of positive predictive values for identification of safety and effectiveness outcomes (ranging from 55.7% to 100%), which were generally adequate compared with clinician chart review after code-based algorithms were used to reduce false-positive cases.

How might these results affect future research or surgical practice?

- These results demonstrate the feasibility of examining the safety and effectiveness of cardiac ablation catheters using real-world health system data.
- Lessons from this study that can help future researchers use real-world health system data to evaluate medical device safety and effectiveness.
- The results from this study also identify opportunities to enhance the completeness and quality of real-world data.

INTRODUCTION

Recent policy changes have increased the salience of real-world data (RWD), which are those data collected during routine clinical care, to generate real-world evidence (RWE) that can support regulatory decision-making.[1]

The 21st Century Cures Act of 2016 placed increasing emphasis on the use of RWE, including for secondary indication approvals for drugs.[2] In 2017, the US Food and Drug Administration (FDA) Center for Devices and Radiological Health released a Guidance Document about this topic, entitled 'Use of RWE to Support Regulatory Decision-Making for Medical Devices'.[3] FDA's Guidance discusses potential RWE use to support expanded indications of use for medical devices. Examples of employing RWE for this purpose include four premarket indication expansion decisions based on data from the Transcatheter Valve Therapeutics Registry.[4] However, registries are specialised RWD sources because they require significant effort and resources, including general reliance on trained abstractors to manually extract and input many data elements.[5] Additionally, registries are usually specialised to a disease state or condition with a limited number of variables because of the cost and time needed for that abstraction and, therefore, are unavailable for all medical devices.

To further the goal of developing timely and robust RWE for informing regulators and clinicians regarding medical device effectiveness and safety, the National Evaluation System for health Technology (NEST) was created.[6] The most ubiquitous sources of RWD and with the greatest clinical detail are health system databases, including electronic health records. However, health system data are not specifically designed for research purposes[1] and their ability to contribute reliable evidence for medical device safety and effectiveness evaluations, including for label expansions, remains uncertain. Since the fall of 2018, the NEST Coordinating Center (NESTcc) has supported multiple test-case studies to investigate the use of RWD, including health system data, in RWE generation that can be used to inform regulatory decision-making. Several test-cases are feasibility assessments focused on the availability of pertinent variables—including medical device use, covariates and safety and effectiveness outcomes.[7] Here, we report on one of the first such test-cases to be completed. In this test-case, we sought to assess the feasibility of using RWD related to two cardiac ablation catheters that were generated during routine clinical practice and extracted from electronic information systems at three health systems to conduct a study that could inform regulatory decision-making for clinical indication expansion. We describe the process of collecting the necessary data, evaluating its reliability and lessons learnt that can inform future work.

METHODS

Project origination

The study was proposed to NESTcc by Johnson & Johnson, with the ultimate objective of evaluating the safety and effectiveness of two cardiac ablation catheters when used in routine clinical practice. The specific catheters of interest are the ThermoCool Smarttouch (ST) catheters, initially approved by FDA in February 2014, and the ThermoCool Smarttouch Surround Flow (STSF) catheters, initially approved by FDA in August 2016.

After independent review, NESTcc funded the project. NESTcc currently includes 16 network collaborators (healthcare providers, academic research institutions, payers and professional registries) that collect, curate and analyse RWD that may be used for regulatory decision-making. Among its network collaborators, NESTcc identified three health systems that were interested in the proposal and that had significant experience with these devices: Mercy Health, Mayo Clinic and Yale-New Haven Hospital. Johnson and Johnson and the three NESTcc network collaborators, with Mercy Health serving as the lead, developed a full research plan that was approved by the NESTcc. Institutional Review Board (IRB) approval was obtained at Mercy Health (IRB submission number 1349229–1, acknowledged as research but not human subjects research), Mayo Clinic (IRB application number 19–001 493, exempt from the requirement for IRB approval) and Yale University (IRB submission number 2000024523, approved for medical record review only).

Overview of participating health systems

Mercy Health is a health system operating in four states in the Midwest with 39 hospitals, 12 outpatient surgery centres and 35 urgent care sites and caring for a population of approximately 4.2 million active patients. Mayo Clinic partially owns and operates the Mayo Clinic health system of 70 hospitals and clinics, serving a population of approximately 1.3 million patients annually. Yale-New Haven Health System is a health system of five hospitals in the Northeast, caring for approximately 2 million patients annually. All three health systems use the same system of electronic health records (EHRs) maintained by the company Epic (Epic Systems, Verona, Wisconsin). For inventory management, the health systems use different systems: OptiFlex at Mercy, QSight at YNHH and Supply + at Mayo Clinic and have different methods for tracking medical devices.

Overall goals and overview of original data collection

The study tested the feasibility of the three independent health systems to obtain RWD from their electronic information systems, including EHRs, to examine the safety and effectiveness of improved irrigation technology, called Surround Flow (SF) to the tip of the ThermoCool cardiac ablation catheter. The informatics methods have been described separately.[8]

The first portion of the study sought to examine the feasibility of demonstrating equivalent safety and effectiveness of the ThermoCool Smarttouch catheter that does not have the SF technology as compared with the ThermoCool catheter that does have this technology, ThermoCool Smarttouch SF. While both catheters have labelled indications for treating paroxysmal atrial fibrillation (AF), only ThermoCool Smarttouch- Surround Flow- (STSF) is labelled for persistent AF; this indication was obtained by an investigational device exemption

clinical trial. The second portion of the study sought to compare the safety and effectiveness of the ThermoCool Smarttouch SF catheter with the ThermoCool Smarttouch and the Navistar catheters for ischaemic ventricular tachycardia (VT); the latter two catheters have a labelled indication for recurrent drug/device refractory sustained monomorphic VT due to prior myocardial infarction, while the Smarttouch SF catheter does not. The Navistar catheter is an earlier form of the ThermoCool catheter initially approved by the FDA in 2006 before contact force monitoring (Smarttouch) and improved cooling irrigation (SF) were added.

This research study first sought to identify the medical devices (ablation catheters) of interest in the health system electronic information systems and then to link to the pertinent patient populations who received treatment with these catheters. Afterwards, the performance of codes/algorithms to identify key safety and effectiveness outcomes of interest (ischaemic stroke, cardiac tamponade, acute heart failure and arrhythmia-related hospitalisation) was compared with clinician chart review in a small sample of patients at each health system (up to 25 patients per health system). All analyses were conducted individually at each health system using a decentralised model[9] ; summary results were shared across researchers from the three institutions, but no patient-level data were shared.

Device, procedure and patient population identification

We identified patients who had received treatment with the medical devices (ablation catheters) of interest. The catheters were identified first (as opposed to the patient cohort), because the use of the catheters was necessary to ensure the feasibility of the study. Different strategies were used at each health system to identify the specific catheters used for ablation, including the device identifier (DI) component of the US FDA required unique DIs (UDIs) that were supplied by Johnson & Johnson and were available in the FDA's Global Unique Device Identification Database. These DIs were identified in supply chain and point-of-care inventory management data. Mayo Clinic also used catalogue numbers. For data prior to 2016, Mercy identified device information used in the procedures from a combination of Healthcare Common Procedure Coding System codes and device billing information from specific charge codes in the EHR (online supplemental table 1). Then, devices were linked to the specific patients who received treatment with them.

Once ablation catheters were identified, we determined types of the ablation procedure and arrhythmia for which the patients underwent ablation. We identified patients who had either AF or VT ablations performed with these catheters using Current Procedural Terminology (CPT) codes associated with the procedures (online supplemental table 2). We further identified the subset of these patients who had persistent AF and VT using International Classification of Diseases (ICD)–9-Clinical Modification (CM) (for VT only) and ICD-10-CM diagnosis codes for their arrhythmia prior to or during the clinical encounter that included the ablation procedure (online supplemental table 3). ICD-9 and 10-CM codes were used after filtering based on CPT codes to add additional specificity, since the CPT codes do not identify the precise patient population of interest. Among patients undergoing AF ablation, defining the persistent AF phenotype was possible with ICD-10-CM, but not with ICD-9-CM, because the latter system does not include codes for AF subtypes. Patients with diagnosis codes only for unspecified AF were excluded, because of inability to subtype their AF. Patients with codes for long-standing persistent AF were included as persistent AF.

Among patients undergoing ablation for VT, classifying patients by ischaemic and non-ischaemic VT required identifying the subset who had prevalent ischaemic heart disease (online supplemental table 4). This decision was based on the assumption that ischaemic heart disease codes, including those for both acute myocardial infarction as well as chronic ischaemic heart disease, would distinguish patients with ischaemic from non-ischaemic VT.

Finally, in order to understand the availability of longitudinal data for outcome ascertainment, we determined the duration of follow-up through in-person encounters of patients receiving catheter ablation within each of the three health systems at 7 days, 30 days, 6 months and 1 year. Only encounters at the end of, or subsequent to, the time period of interest were included. Follow-up was defined as an encounter identified using an algorithm of in-person contact that included both face-to-face visits and remote contact, such as telephone visits, with any representative at the given health system. These encounters were not limited to those with cardiology clinicians.

Clinical outcomes

Pertinent clinical outcomes for patients undergoing ablation for AF or VT were then identified using ICD-9-CM and ICD-10-CM diagnosis and procedure codes and CPT codes (CPT codes were used for cardiac tamponade) based on previous publications,[10 11] domain knowledge and the National Institute of Health's Value Set Authority Center (online supplemental table 5).[12] A panel of four cardiologists, including three cardiac electrophysiologists, then reviewed the list of codes and consensus was reached on the codes for inclusion using a modified Delphi process. The diagnosis codes listed as the primary discharge diagnoses were then applied to health system data to identify patients with the clinical outcome of interest. Physicians on the research team then performed manual chart review to determine the positive predictive value (PPV) of these code algorithms relative to clinician verification within the patient population of interest. When there were 25 or fewer events, all charts were reviewed. When there were more than 25, then 25 randomly selected patient charts for each of three serious safety outcomes (ischaemic stroke, cardiac tamponade and acute heart failure) and a single effectiveness outcome (arrhythmia-related hospitalisation) were reviewed. The goal of this analysis

Table 1 Number of times that the ablation catheters of interest were used across all procedures, by health system

Health system	ThermoCool ST	ThermoCool ST SF
Mercy Health (1 January 2014–7 August 2019)	1329	740
Mayo Clinic (1 January 2014–31 December 2018)	2545	401
Yale New Haven Hospital (1 October 2017–30 June 2019)	406	375
Total	4280	1516

was to determine whether a specific outcome of interest, focusing on outcomes commonly assessed in randomised controlled trials of ablation catheters,[13 14] was accurately identified in a broad population of patients with the algorithm. The number of charts selected for each clinical event reflected both the number of patients identified with a given event in a broad patient cohort within each health system's data and resources for performing chart review. We calculated the 95% CIs based on the efficient-score method.[15]

RESULTS

Device identification

Device data were obtained from 1 January 2014 through 7 August 2019 at Mercy Health, from 1 January 2014 through 31 December 2018 at Mayo Clinic and from 1 October 2017 through 30 June 2019 at Yale New Haven Hospital (YNHH). In total, 4280 ablations were performed for patients with the catheter being investigated for persistent AF (ThermoCool ST), ranging from 406 at YNHH to 2545 at Mayo Clinic (although there were more than 3 years fewer data at YNHH due to inability to ascertain device). Overall, 1516 ablations were performed with the catheter being investigated for ischaemic VT (Thermocool ST SF), ranging from 375 at YNHH to 740 at Mercy Health (table 1).

Patient population

EHR data were obtained from 1 January 2014 through 20 February 2020 at Mercy Health; 1 January 2014 through 31 December 2019 at Mayo Clinic; and 1 February 2013 through 13 August 2019 at YNHH (additional data through 31 December 2019 were obtained for longitudinal follow-up). Overall, a total of 357 181 patients with AF were identified, including 27 864 patients with persistent AF and 266 001 patients with ICD codes for 'unspecified' and 'other' AF (patients were allowed to have multiple diagnoses for types of AF). In total, 59 425 patients with VT were identified, including 39 092 with ischaemic VT.

A large proportion of patients had ICD-10-CM codes for various combinations of paroxysmal, persistent and chronic AF as well as the non-specific ICD-9-CM codes. In these instances, codes for paroxysmal AF did not necessarily appear in the record first with codes for persistent AF entered at a later date, even though this is the well-established disease progression.[16] The ultimate decision was to use the ICD-10-CM diagnosis codes for the ablation procedure. If there were multiple codes, then the most advanced in terms of expected disease progression was selected.

With regards to ablation, we identified 8676 ablation procedures for AF, ranging from 1299 at YNHH to 4906 at Mayo Clinic (table 2). We identified 1865 ablation procedures for VT, ranging from 198 at Mercy to 1140 at Mayo Clinic. An additional 8676 ablations had another primary diagnosis or a missing primary diagnosis.

Evaluation of follow-up

The duration of patient follow-up as ascertained using information from each of the three health system's EHRs ranged from 91% to 97% at ≥7 days, 89% to 96% at ≥30 days, 77% to 90% at ≥6 months, and 66% to 84% at ≥1 year (figure 1). Investigation of follow-up at YNHH identified that YNHH's electrophysiology laboratory has allowed non-YNHH physicians to perform procedures

Table 2 Cardiac catheter ablation procedure counts within the populations of interest (atrial fibrillation and ventricular tachycardia)

Health system	Ablation procedures (AF population)	Ablation procedures (VT population)	Ablation procedures ('other primary' and 'missing primary')	Total
Mercy Health (1 January 2014–20 February 2020)	2471	198	2530	5199
Mayo Clinic (1 January 2014–31 December 2019)	4906	1140	3142	8932
Yale New Haven Hospital (1 February 2013–13 August 2019)	1299	527	3004	4830
Total	8676	1865	8676	18 961

AF, atrial fibrillation; VT, ventricular tachycardia.

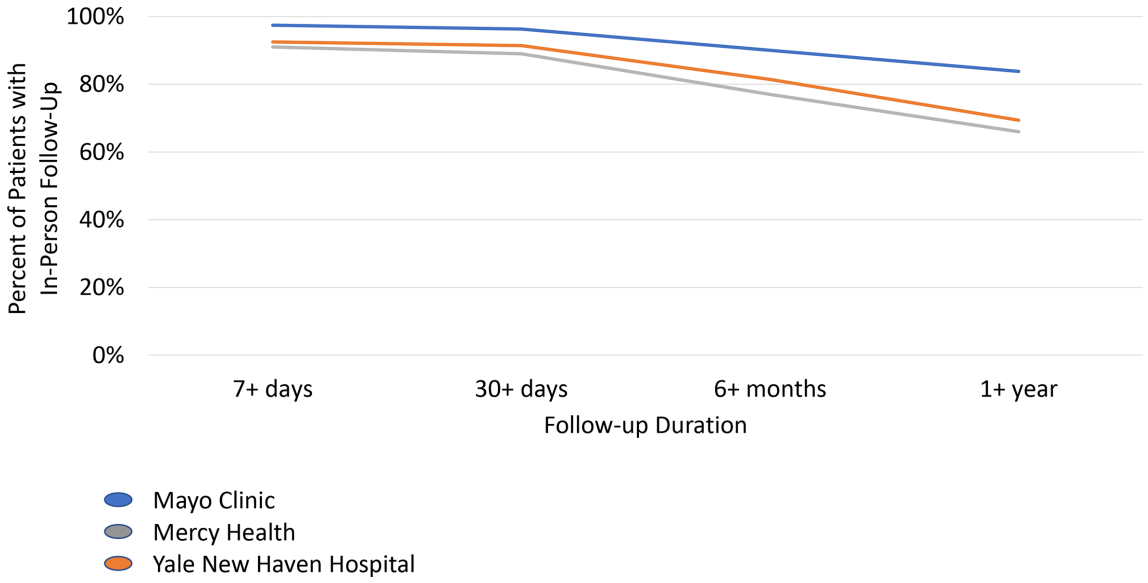

Figure 1 In-person follow-up encounters for patients after catheter ablation. Mercy data are for all ablation procedures from 2009 through 2018; Yale New Haven Hospital data are for all ablation procedures between February 2013 and August 2019; Mayo Clinic data are for all ablation procedures between January 2009 and December 2020.

there, and some YNHH physicians follow patients at non-YNHH clinics; therefore, these patients' follow-up would not be within YNHH's EHR.

Positive predictive values of codes/algorithms for clinical outcomes

Overall, PPVs were 96.4% for acute heart failure, ranging from 80% to 100% with between 10 and 25 charts reviewed at each health system (table 3). For ischaemic stroke, the overall PPV was 63.4%; this included 29.2%, 91.7% and 100% at the three health systems with between 4 and 24 charts reviewed. The PPV for cardiac tamponade was 100%, with two charts reviewed at one health system. The overall PPV for the effectiveness endpoint, arrhythmia-related hospitalisation, was 55.7% and ranged from 26.7% to 84.0% with between 15 and 25 charts reviewed.

Data resource use

A key factor in assessing the feasibility of using the NESTcc Network Collaborator EHR databases for evaluation of safety and effectiveness is whether the sample size is sufficient. Based on the feasibility study's catheter ablation procedure counts and the anticipated increase in procedure numbers, it was expected that the sample size will be adequate to conduct a study using RWD from two of these participating health systems with high follow-up rates to examine expansion of indication of cardiac catheters to treat ischaemic VT and persistent AF. This phase 2 study is further evaluating and refining codes/algorithms for identification of patient populations, covariates and outcomes and will be focused on both short-term and long-term safety and effectiveness outcomes and could be the first label expansion study that solely uses electronic data from health systems.

DISCUSSION

In this study, we determined that the participating health systems had used adequate numbers of ThermoCool catheters and could obtain data of sufficient quality from their electronic information systems to evaluate the safety and effectiveness of cardiac ablation catheters. There were several important lessons learnt from this feasibility

Table 3 Positive predictive values of algorithms for primary diagnosis codes of safety and effectiveness outcomes based on physician-led chart reviews

Clinical outcome	Mercy Health	Mayo Clinic	Yale New Haven Hospital
Acute heart failure	21/21 (100%; 95% CI, 80.8% to 100%)	25/25 (100%; 95% CI, 83.4% to 100%)	8/10 (80.0%; 95% CI, 44.2% to 96.5%)
Ischaemic stroke	22/24 (91.7%; 95% CI, 71.5% to 98.5%)	7/24 (29.2%; 95% CI, 13.4% to 51.2%)	4/4 (100%; 95% CI, 39.6% to 100%)
Arrhythmia hospitalisation	9/21 (42.9%; 95% CI, 22.6% to 65.6%)	21/25 (84.0%; 95% CI, 63.1% to 94.7%)	4/15 (26.7%; 95% CI 8.9% to 55.2%)
Cardiac tamponade	None reported	Not explored	2/2 (100%; 95% CI, 19.8% to 100%)

study, which will not only inform our investigations of the ablation catheters in question but also the use of RWD generally for medical device-specific studies.

A key strength was the successful use of a decentralised model for research.[8] All three health systems retained their data behind their individual firewalls, but data were collected using common definitions that will enable research using distributed analytics. This will provide a much larger sample size than from a single health system. The infrastructure was additionally built for two similar studies (focused on persistent AF and ischaemic VT); these commonalities suggest that a reusable infrastructure can be created for answering multiple research questions about real-world medical device safety and effectiveness.

In addition, several challenges were encountered in the feasibility stage of this research as well as insights that have led us to conclude that the challenges are all addressable. An overall challenge was that diagnostic codes lacked sufficient resolution for creating patient cohorts, which may necessitate expanding data types used for computed phenotypes. ICD-9-CM codes lack specificity for subtypes of AF. Because our ablation indication of interest was persistent AF, this prevents analysis of specific phenotypes of atrial fibrillation and would require alternative extraction approaches. Fortunately, the ICD-10-CM transition (1 October 2015) provides additional detail to AF subtypes. However, many patients had non-specific ICD-10-CM codes recorded; if the specific AF subtype cannot be documented, these patients may be dropped as they cannot be determined to have persistent AF. One option to address this challenge is to create and validate an algorithm (eg, such as including the use of antiarrhythmic medications) that may increase probability a patient has persistent AF. We also can use the Mayo Clinic cardiac ablation registry, a quality improvement database that captures most ablations with nurse-abstracted data, to validate our coding algorithms for identifying persistent AF. Additionally, Mercy has previously validated natural language processing algorithms to identify patients with persistent AF in Mercy's notes text. To ensure a consistent definition of AF, we started with use of the ICD-10-CM diagnosis code at the time of the ablation procedure. If there were multiple codes, we considered refining based on disease progression in future decision-making.

Similarly, while there are codes for identification of VT ablation, there are no specific ICD-9-CM or ICD-10-CM codes for identification of ablation of ischaemic VT. Patients were determined to have ischaemic VT using ICD-9-CM and ICD-10-CM diagnosis codes for ischaemic heart disease,[17] assuming these codes in a patient's history would indicate an ischaemic aetiology of VT. The accuracy of these diagnostic codes, and what look-back period to use, for ischaemic heart disease is unclear.

Second, using health system data to create a cohort of patients who underwent the procedure of interest using a specific device has challenges. Ascertainment of pertinent covariates using prior diagnosis codes may be limited unless patients were cared for routinely within a health system prior to the procedure. Missing data for this reason has been termed EHR-discontinuity and can risk biasing studies through misclassification of confounding variables and outcomes.[18] A solution is to use an algorithm to identify patients with high data completeness in the EHR.[18] For patients receiving ablation within a referral centre, chart histories of covariates (eg, prior ablation) may not be in discrete fields and, thus, may be incompletely ascertained if only automated extraction is used and, thus, limit accurate risk adjustment. However, these data may be available to a manual abstractor. Another potential solution is linkage with insurer claims data, such as Medicare fee-for-service claims, or registry data. (There are currently multiple national AF ablation registries and sometimes local registries, such as the Mayo Clinic cardiac ablation registry.) Another challenge is that other covariates that describe how the catheter was used may not be in the EHR or captured by current coding algorithms; this is particularly important as different operators may use different ablation techniques, and ablation techniques, such as the use of high-power short-duration ablation, may evolve over time. A solution is to use procedural data captured by the ablation technology during the procedure that records numerous parameters employed by the operator, including power, contact force, lesion duration, continuous versus point-by-point ablation and lesion sets, which are not captured with ICD codes. Additionally, important covariates such as centre ablation volume and operator experience can be obtained from health system data.

Third, ensuring that patients have sufficient follow-up within the given health system is important for long-term outcome ascertainment, particularly at regional referral centres. In-hospital complications will nearly always be captured. However, postdischarge, patients may receive care at outside health systems. If they experience a complication, they may present to the nearest emergency department, geographically distant from the centre where the ablation procedure was performed. Follow-up decreased progressively from 7 days to 30 days to 6 months and then to 1 year. We found that at least two-thirds of patients had follow-up at 1 year for all three participating health systems. Follow-up beyond 1 year is likely to be challenging. However, because we did not capture care at outside health systems, it is possible that this may undercount pertinent clinical conditions or events, including hospitalizations; although possible, we do not think that such missed events are likely to occur often when patients continue to see clinicians within the same health system. Low follow-up data capture rates in individual health system EHRs must, nevertheless, be identified. Strategies to improve data capture, such as through patient-centred digital health data sharing platforms that track outcomes in multiple EHR systems,[19] could increase the amount of available follow-up data. Another possible solution is identification of a subpopulation that likely has follow-up within the health system where the ablation is performed (eg, within a close geographic radius or receiving primary and/or cardiology care within the health system). Finally,

linkage to claims or registry data could provide additional follow-up.

Fourth, although a small number of patients were identified with the four outcomes of interest, there was variability in the PPVs of using diagnosis codes to identify the safety outcomes of interest across outcomes and across healthcare systems, despite filtering on primary discharge diagnosis codes. For example, the PPVs for identification of stroke at one health system were relatively low, which may have resulted from the inability of the algorithm to distinguish patients with acute strokes from those with history of prior stroke. Using primary discharge diagnosis codes for hospitalizations for serious events like stroke may be less subject to misclassification than codes from outpatient visits. However, some patients with peri-procedural safety events may be missed by reliance solely on primary diagnosis codes, since safety events that occur during the procedure may be entered as secondary diagnoses while the primary diagnosis is used for the morbidity that led to the procedure. Both primary and secondary diagnoses codes should likely be used. Mid-term and long-term evaluation for events like heart failure that have a high background rate in the target population may make it difficult to differentiate between a prior event and a treatment-related occurrence using diagnostic codes alone. Finally, additional clinically important outcomes, such as atrio-oesophageal fistula and pulmonary vein stenosis, which are expected to be identified only at longer duration of follow-up, also need to be identified.

There are multiple possible solutions for improving accuracy of outcome ascertainment, which are similar to the strategies to address cohort identification. For example, prior studies have validated a variety of diagnosis codes against chart review in electronic health record studies.[11] Additionally, tools for phenotype development and evaluation using machine learning approaches are increasingly being made available to assist these efforts.[20] Ultimately, comparing the diagnostic codes or algorithms (composed of several codes for presence, absence, timing, setting and coincident diagnoses and treatments) with clinician review of electronic health records to determine extent of concordance between codes and clinical judgement may be necessary. While our study only had the resources to examine PPVs and sometimes identified smaller numbers of adverse events than would be expected based on the peer-reviewed literature, our study is limited because we did not assess negative predictive values, sensitivity, specificity, and accuracy of outcome ascertainment among patients with adequate follow-up within health systems to ensure that outcomes are not missed. If coding algorithms fail to perform adequately in this regard, an alternative approach to safety event identification will be considered. A group of patients at high risk of the outcome of interest who have negative results on the algorithm to detect the outcome of interest will require manual review, which can be time-consuming. Such analyses should examine specific sections of a patient's EHR data, such as clinical notes where, if a given clinical event had occurred, it would be recorded. For example, cardiology or cardiac electrophysiology notes should capture ablation-related complications. This approach has been used successfully in validating algorithms to detect opioid overdose[21] and addiction[22] in postmarketing studies overseen by the FDA. In our study, it is possible that clinicians who performed the chart review were, in some cases, the same as those performing the procedures; it is possible that this could bias towards undercounting of adverse events. While this potential source of bias is not critical in a feasibility study of this type, efforts will be needed to ensure that methods are unbiased and consistent across different sites in a study of device effectiveness and safety.

Finally, effectiveness outcomes need to be carefully chosen to ensure that they are meaningful patient-oriented metrics. While we did not evaluate efficacy end points in this study, for future research, we decided to use clinical outcomes that reflect sequelae of arrhythmia recurrence: for AF, this includes rehospitalisation for AF or interventions addressing a new atrial tachyarrhythmia, including cardioversion, repeat ablation or new antiarrhythmic drug prescription; for ischaemic VT, this includes hospitalisation for VT or repeat ablation as well as heart failure, since that can be a sequela of VT. These are meaningful measures of effectiveness since the goal of ablation is to prevent additional treatment for an arrhythmia or serious consequences thereof, primarily heart failure, recurrent VT and mortality. Arrhythmia ICD diagnosis and procedure codes alone (ie, AF or VT codes) for outcome identification may have low PPVs because clinicians may add these codes of past events to follow-up visits since they can help with medical history or reimbursement. Even relying on primary diagnosis codes may not be sufficient, and manual chart review may be necessary to improve PPV and, therefore, it may not be easily achievable. In the case of AF, for example, physicians may maintain the diagnosis for clinic visits if patients are continued on therapeutic anticoagulation for thromboembolism prophylaxis. We found that PPVs using this approach for arrhythmia-related hospitalisation had variation across health systems (27%, 43% and 84%); but, because the numbers assessed were small, the CIs around the point estimates of several outcomes were overlapping. Additionally, for patients with AF, a blanking period (ie, time period when arrhythmia recurrences are not included) needs to be considered, given the high recurrence rate during this 60-day or 90-day period postablation.[23] Other data sources that could be helpful for outcome ascertainment, such as results from electrocardiograms, outpatient rhythm monitors or cardiac implantable electronic device (ie, pacemaker, implantable cardioverter defibrillator or implantable loop recorder) interrogations, were evaluated and found to be not feasible to easily obtain from the EHR databases used in our study; however, novel approaches are creating methods to import these data in standardised formats.

CONCLUSIONS

RWD collected during routine care present tremendous promise for use in medical device evaluations. The current feasibility study demonstrates the potential for evaluating the safety and effectiveness of new technology added to cardiac ablation catheters along with the challenges inherent in performing studies using health system data. The feasibility study also describes strategies to overcome these challenges and to help make RWD fit-for-purpose to generate RWE that can be used to support decisions by regulators, payers, clinicians and patients.

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Supplementary Material

Supplementary Table 1: Healthcare Common Procedure Coding System (HCPCS) Codes for Catheters Used During Cardiac Ablation

Code	Code Description
C1732	Catheter, electrophysiology, diagnostic/ablation, 3d or vector mapping
C1733	Catheter, electrophysiology, diagnostic/ablation, other than 3d or vector mapping, other than cool-tip
C2630	Catheter, electrophysiology, diagnostic/ablation, other than 3d or vector mapping, cool-tip

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Supplementary Table 2: Current Procedural Terminology (CPT) Codes for Procedures of Interest

Code	Code Description
93654	Comprehensive electrophysiologic evaluation including insertion and repositioning of multiple electrode catheters with induction or attempted induction of an arrhythmia with right atrial pacing and recording, right ventricular pacing and recording (when necessary), and His bundle recording (when necessary) with intracardiac catheter ablation of arrhythmogenic focus; with treatment of ventricular tachycardia or focus of ventricular ectopy including intracardiac electrophysiologic 3D mapping, when performed, and left ventricular pacing and recording, when performed
93656	Comprehensive electrophysiologic evaluation including transseptal catheterizations, insertion and repositioning of multiple electrode catheters with induction or attempted induction of an arrhythmia including left or right atrial pacing/recording when necessary, right ventricular pacing/recording when necessary, and His bundle recording when necessary with intracardiac catheter ablation of atrial fibrillation by pulmonary vein isolation
93657	Additional linear or focal intracardiac catheter ablation of the left or right atrium for treatment of atrial fibrillation remaining after completion of pulmonary vein isolation (List separately in addition to code for primary procedure)

Supplementary Table 3: International Classification of Diseases (ICD)-9-Clinical Modification (CM), ICD-10-CM, and SNOMED CT Codes for Patient Populations of Interest

Population of Interest	Source	Code	Code Description
Patients with atrial fibrillation had at least one of the following diagnosis codes prior to or during the clinical encounter that included the ablation procedure	ICD-9-CM	427.31	Atrial fibrillation
	ICD-10-CM	I48.0	Paroxysmal atrial fibrillation
	ICD-10-CM	I48.1	Persistent atrial fibrillation
	ICD-10-CM	I48.2	Chronic atrial fibrillation
	ICD-10-CM	I48.91	Unspecified atrial fibrillation
Patients with ventricular tachycardia: had at least one of the following diagnosis codes prior to or during the clinical encounter that included the ablation procedure	ICD-9-CM	427.1	Paroxysmal ventricular tachycardia
	ICD-10-CM	I47.2	Ventricular tachycardia

Supplementary Table 4: International Classification of Diseases (ICD)-9-Clinical Modification (CM) and ICD-10-CM for Patients with Ischemic Heart Disease

Source	Code	Code Description
ICD-9-CM	410.00	Acute myocardial infarction of anterolateral wall, episode of care unspecified
ICD-9-CM	410.01	Acute myocardial infarction of anterolateral wall, initial episode of care
ICD-9-CM	410.02	Acute myocardial infarction of anterolateral wall, subsequent episode of care
ICD-9-CM	410.10	Acute myocardial infarction of other anterior wall, episode of care unspecified
ICD-9-CM	410.11	Acute myocardial infarction of other anterior wall, initial episode of care
ICD-9-CM	410.12	Acute myocardial infarction of other anterior wall, subsequent episode of care
ICD-9-CM	410.20	Acute myocardial infarction of inferolateral wall, episode of care unspecified
ICD-9-CM	410.21	Acute myocardial infarction of inferolateral wall, initial episode of care
ICD-9-CM	410.22	Acute myocardial infarction of inferolateral wall, subsequent episode of care
ICD-9-CM	410.30	Acute myocardial infarction of inferoposterior wall, episode of care unspecified
ICD-9-CM	410.31	Acute myocardial infarction of inferoposterior wall, initial episode of care
ICD-9-CM	410.32	Acute myocardial infarction of inferoposterior wall, subsequent episode of care
ICD-9-CM	410.40	Acute myocardial infarction of other inferior wall, episode of care unspecified
ICD-9-CM	410.41	Acute myocardial infarction of other inferior wall, initial episode of care
ICD-9-CM	410.42	Acute myocardial infarction of other inferior wall, subsequent episode of care
ICD-9-CM	410.50	Acute myocardial infarction of other lateral wall, episode of care unspecified
ICD-9-CM	410.51	Acute myocardial infarction of other lateral wall, initial episode of care
ICD-9-CM	410.52	Acute myocardial infarction of other lateral wall, subsequent episode of care
ICD-9-CM	410.60	True posterior wall infarction, episode of care unspecified
ICD-9-CM	410.61	True posterior wall infarction, initial episode of care
ICD-9-CM	410.62	True posterior wall infarction, subsequent episode of care
ICD-9-CM	410.70	Subendocardial infarction, episode of care unspecified
ICD-9-CM	410.71	Subendocardial infarction, initial episode of care
ICD-9-CM	410.72	Subendocardial infarction, subsequent episode of care
ICD-9-CM	410.80	Acute myocardial infarction of other specified sites, episode of care unspecified
ICD-9-CM	410.81	Acute myocardial infarction of other specified sites, initial episode of care
ICD-9-CM	410.82	Acute myocardial infarction of other specified sites, subsequent episode of care
ICD-9-CM	410.90	Acute myocardial infarction of unspecified site, episode of care

		unspecified
ICD-9-CM	410.91	Acute myocardial infarction of unspecified site, initial episode of care
ICD-9-CM	410.92	Acute myocardial infarction of unspecified site, subsequent episode of care
ICD-9-CM	411.89	Other acute and subacute forms of ischemic heart disease, other
ICD-9-CM	412	Old myocardial infarction
ICD-9-CM	414.00	Coronary atherosclerosis of unspecified type of vessel, native or graft
ICD-9-CM	414.01	Coronary atherosclerosis of native coronary artery
ICD-9-CM	414.02	Coronary atherosclerosis of autologous vein bypass graft
ICD-9-CM	414.03	Coronary atherosclerosis of nonautologous biological bypass graft
ICD-9-CM	414.04	Coronary atherosclerosis of artery bypass graft
ICD-9-CM	414.05	Coronary atherosclerosis of unspecified bypass graft convert
ICD-9-CM	414.06	Coronary atherosclerosis of native coronary artery of transplanted heart
ICD-9-CM	414.07	Coronary atherosclerosis of bypass graft (artery) (vein) of transplanted heart
ICD-9-CM	414.2	Chronic total occlusion of coronary artery
ICD-9-CM	414.3	Coronary atherosclerosis due to lipid rich plaque
ICD-9-CM	414.4	Coronary atherosclerosis due to calcified coronary lesion
ICD-9-CM	414.8	Other specified forms of chronic ischemic heart disease
ICD-9-CM	414.9	Chronic ischemic heart disease, unspecified
ICD-10-CM	I21.01	ST elevation (STEMI) myocardial infarction involving left main coronary artery
ICD-10-CM	I21.02	ST elevation (STEMI) myocardial infarction involving left anterior descending coronary artery
ICD-10-CM	I21.09	ST elevation (STEMI) myocardial infarction involving other coronary artery of anterior wall
ICD-10-CM	I21.11	ST elevation (STEMI) myocardial infarction involving right coronary artery
ICD-10-CM	I21.19	ST elevation (STEMI) myocardial infarction involving other coronary artery of inferior wall
ICD-10-CM	I21.21	ST elevation (STEMI) myocardial infarction involving left circumflex coronary artery
ICD-10-CM	I21.29	ST elevation (STEMI) myocardial infarction involving other sites
ICD-10-CM	I21.3	ST elevation (STEMI) myocardial infarction of unspecified site
ICD-10-CM	I21.4	Non-ST elevation (NSTEMI) myocardial infarction
ICD-10-CM	I22.0	Subsequent ST elevation (STEMI) myocardial infarction of anterior wall
ICD-10-CM	I22.1	Subsequent ST elevation (STEMI) myocardial infarction of inferior wall
ICD-10-CM	I22.2	Subsequent non-ST elevation (NSTEMI) myocardial infarction
ICD-10-CM	I22.8	Subsequent ST elevation (STEMI) myocardial infarction of other sites
ICD-10-CM	I22.9	Subsequent ST elevation (STEMI) myocardial infarction of unspecified site
ICD-10-CM	I24.8	Other forms of acute ischemic heart disease
ICD-10-CM	I24.9	Acute ischemic heart disease, unspecified
ICD-10-CM	I25.10	Atherosclerotic heart disease of native coronary artery without angina pectoris
ICD-10-CM	I25.110	Atherosclerotic heart disease of native coronary artery with unstable angina pectoris

ICD-10-CM	I25.111	Atherosclerotic heart disease of native coronary artery with documented spasm
ICD-10-CM	I25.118	Atherosclerotic heart disease of native coronary artery with other forms of angina pectoris
ICD-10-CM	I25.119	Atherosclerotic heart disease of native coronary artery with unspecified angina
ICD-10-CM	I25.2	Old myocardial infarction
ICD-10-CM	I25.5	Ischemic cardiomyopathy
ICD-10-CM	I25.700	Atherosclerosis of coronary artery bypass graft(s), unspecified, with unstable angina pectoris
ICD-10-CM	I25.701	Atherosclerosis of coronary artery bypass graft(s), unspecified, with documented spasm
ICD-10-CM	I25.708	Atherosclerosis of coronary artery bypass graft(s), unspecified, with other forms of angina pectoris
ICD-10-CM	I25.709	Atherosclerosis of coronary artery bypass graft(s), unspecified, with unspecified angina pectoris
ICD-10-CM	I25.710	Atherosclerosis of autologous vein coronary artery bypass graft(s) with unstable angina pectoris
ICD-10-CM	I25.711	Atherosclerosis of autologous vein coronary artery bypass graft(s) with documented spasm
ICD-10-CM	I25.718	Atherosclerosis of autologous vein coronary artery bypass graft(s) with other forms of angina pectoris
ICD-10-CM	I25.719	Atherosclerosis of autologous vein coronary artery bypass graft(s) with unspecified angina pectoris
ICD-10-CM	I25.720	Atherosclerosis of autologous artery coronary artery bypass graft(s) with unstable angina pectoris
ICD-10-CM	I25.721	Atherosclerosis of autologous artery coronary artery bypass graft(s) with documented spasm
ICD-10-CM	I25.728	Atherosclerosis of autologous artery coronary artery bypass graft(s) with other forms of angina pectoris
ICD-10-CM	I25.729	Atherosclerosis of autologous artery coronary artery bypass graft(s) with unspecified angina pectoris
ICD-10-CM	I25.730	Atherosclerosis of nonautologous biological coronary artery bypass graft(s) with unstable angina pectoris
ICD-10-CM	I25.731	Atherosclerosis of nonautologous biological coronary artery bypass graft(s) with documented spasm
ICD-10-CM	I25.738	Atherosclerosis of nonautologous biological coronary artery bypass graft(s) with other forms of angina pectoris
ICD-10-CM	I25.739	Atherosclerosis of nonautologous biological coronary artery bypass graft(s) with unspecified angina pectoris
ICD-10-CM	I25.750	Atherosclerosis of native coronary artery of transplanted heart with unstable angina
ICD-10-CM	I25.751	Atherosclerosis of native coronary artery of transplanted heart with documented spasm
ICD-10-CM	I25.758	Atherosclerosis of native coronary artery of transplanted heart with other forms of angina pectoris
ICD-10-CM	I25.759	Atherosclerosis of native coronary artery of transplanted heart with unspecified angina pectoris

ICD-10-CM	I25.760	Atherosclerosis of bypass graft of coronary artery of transplanted heart with unstable angina
ICD-10-CM	I25.761	Atherosclerosis of bypass graft of coronary artery of transplanted heart with documented spasm
ICD-10-CM	I25.768	Atherosclerosis of bypass graft of coronary artery of transplanted heart with other forms of angina pectoris
ICD-10-CM	I25.769	Atherosclerosis of bypass graft of coronary artery of transplanted heart with unspecified angina pectoris
ICD-10-CM	I25.790	Atherosclerosis of other coronary artery bypass graft(s) with unstable angina pectoris
ICD-10-CM	I25.791	Atherosclerosis of other coronary artery bypass graft(s) with documented spasm
ICD-10-CM	I25.798	Atherosclerosis of other coronary artery bypass graft(s) with other forms of angina pectoris
ICD-10-CM	I25.799	Atherosclerosis of other coronary artery bypass graft(s) with unspecified angina pectoris
ICD-10-CM	I25.810	Atherosclerosis of coronary artery bypass graft(s) without angina pectoris
ICD-10-CM	I25.811	Atherosclerosis of native coronary artery of transplanted heart without angina pectoris
ICD-10-CM	I25.812	Atherosclerosis of bypass graft of coronary artery of transplanted heart without angina pectoris
ICD-10-CM	I25.82	Chronic total occlusion of coronary artery
ICD-10-CM	I25.83	Coronary atherosclerosis due to lipid rich plaque
ICD-10-CM	I25.84	Coronary atherosclerosis due to calcified coronary lesion
ICD-10-CM	I25.89	Other forms of chronic ischemic heart disease
ICD-10-CM	I25.9	Chronic ischemic heart disease, unspecified

Supplementary Table 5: Algorithms for Clinical Outcomes of Interest (Ischemic Stroke, Cardiac Tamponade, Acute Heart Failure, and Arrhythmia-related Hospitalization) using International Classification of Diseases (ICD)-9-Clinical Modification (CM), ICD-10-CM, ICD-10-Procedure Coding System (PCS), Healthcare Common Procedure Coding System (HCPCS), and Current Procedural Terminology Codes

Ischemic Stroke Algorithm

Consider ICD codes from hospitalizations including inpatient or emergency department only
Exclude patient/hospitalization if any traumatic brain injury (ICD-9-CM 800-804, 850-854. ICD-10-CM related to traumatic brain injury – please see below) present pre-ablation on/before ischemic stroke indication
Include patient if presence of:
ICD-9-CM 434.x1 (Cerebral embolism/occlusion misc)
ICD-9-CM 362.31 (Central retinal artery occlusion)
ICD-10-CM I63.x (Cerebral infarction misc)
ICD-10-CM H34.1x (Central retinal artery occlusion misc)

Cardiac Tamponade Algorithm

Consider ICD codes from hospitalizations including inpatient or emergency department only
Include patient if presence of:
ICD-9-PCS: 37.0 (pericardiocentesis)
ICD-9-CM 423.3 (Cardiac tamponade)
ICD-9-CM 423.0 (Hemopericardium)
ICD-10-CM I31.4 (Cardiac tamponade)
ICD-10-CM I31.2 (Hemopericardium, not elsewhere classified
ICD-10-PCS 0W9C30Z (Drainage of Mediastinum with Drainage Device, Percutaneous Approach)
ICD-10-PCS 0W9C3ZZ (Drainage of Mediastinum, Percutaneous Approach_
ICD-10-PCS 0W9D30Z (Drainage of Pericardial Cavity with Drainage Device, Percutaneous Approach)
ICD-10-PCS 0W9D3ZX (Drainage of Pericardial Cavity, Percutaneous Approach, Diagnostic)
ICD-10-PCS 0W9D3ZZ (Drainage of Pericardial Cavity, Percutaneous Approach)
ICD-10-PCS 0W9D40Z (Drainage of Pericardial Cavity with Drainage Device, Percutaneous Endoscopic Approach)
ICD-10-PCS 0W9D4ZX (Drainage of Pericardial Cavity, Percutaneous Endoscopic Approach, Diagnostic)
ICD-10-PCS 0W9D4ZZ (Drainage of Pericardial Cavity, Percutaneous Endoscopic Approach)
HCPCS/CPT code G9408 (Cardiac tamponade and/or pericardiocentesis occurring within 30 days)

Acute Heart Failure Algorithm

Consider ICD codes from hospitalizations including inpatient or emergency department only

Exclude patient/hospitalization if it does not include at least one dose of intravenous diuresis from 1-day post-ablation to 30 days post-ablation.
Include patient if presence of:
ICD-9-CM 428.21 (Acute systolic heart failure)
ICD-9-CM 428.23 (Acute on chronic systolic heart failure)
ICD-9-CM 428.31 (Acute diastolic heart failure)
ICD-9-CM 428.33 (Acute on chronic diastolic heart failure)
ICD-9-CM 428.41 (Acute combined systolic and diastolic heart failure)
ICD-10-CM I50.811 (Acute right heart failure)
ICD-10-CM I50.813 (Acute on chronic right heart failure)
ICD-10-CM I50.21 (Acute systolic [congestive] heart failure)
ICD-10-CM I50.23 (Acute on chronic systolic [congestive] heart failure)
ICD-10-CM I50.31 (Acute diastolic [congestive] heart failure)
ICD-10-CM I50.33 (Acute on chronic diastolic [congestive] heart failure)
ICD-10-CM I50.41 (Acute combined systolic [congestive] and diastolic [congestive] heart failure)
ICD-10-CM I50.43 (Acute on chronic combined systolic [congestive] and diastolic [congestive] heart failure)

Arrhythmia-related Hospitalization Algorithm

Include patient if presence of:
ICD-9-CM 427.2 (Paroxysmal tachycardia, unspecified)
ICD-9-CM 427.31 (Atrial fibrillation)
ICD-9-CM 427.32 (Atrial flutter)
ICD-9-CM 427.4 (Ventricular fibrillation and flutter)
ICD-9-CM 427.42 (Ventricular flutter)
ICD-9-CM 427.41 (Ventricular fibrillation)
ICD-10-CM I46.2 (Cardiac arrest due to underlying cardiac condition)
ICD-10-CM I47.0 (Re-entry ventricular arrhythmia)
ICD-10-CM I47.1 (Supraventricular tachycardia)
ICD-10-CM I47.2 (Ventricular tachycardia)
ICD-10-CM I48.0 (Paroxysmal atrial fibrillation)
ICD-10-CM I48.1 (Persistent atrial fibrillation)
ICD-10-CM I48.2 (Chronic atrial fibrillation)
ICD-10-CM I48.3 (Typical atrial flutter)
ICD-10-CM I48.4 (Atypical atrial flutter)
ICD-10-CM I48.91 (Unspecified atrial fibrillation)
ICD-10-CM I48.92 (Unspecified atrial flutter)
ICD-10-CM I49.01 (Ventricular fibrillation)
ICD-10-CM I49.02 (Ventricular fibrillation)
ICD-10-CM I46.9 (Cardiac arrest, cause unspecified)

Codes related to Traumatic Brain Injury Excluded from Ischemic Stroke Definition

S0190XA	Unspecified open wound of unspecified part of head, initial encounter
S020XXA	Fracture of vault of skull, initial encounter for closed fracture
S020XXB	Fracture of vault of skull, initial encounter for open fracture
S02101A	Fracture of base of skull, right side, initial encounter for closed fracture
S02101B	Fracture of base of skull, right side, initial encounter for open fracture
S02102A	Fracture of base of skull, left side, initial encounter for closed fracture
S02102B	Fracture of base of skull, left side, initial encounter for open fracture
S02109A	Fracture of base of skull, unspecified side, initial encounter for closed fracture
S02109B	Fracture of base of skull, unspecified side, initial encounter for open fracture
S02110A	Type I occipital condyle fracture, unspecified side, initial encounter for closed fracture
S02110B	Type I occipital condyle fracture, unspecified side, initial encounter for open fracture
S02111A	Type II occipital condyle fracture, unspecified side, initial encounter for closed fracture
S02111B	Type II occipital condyle fracture, unspecified side, initial encounter for open fracture
S02112A	Type III occipital condyle fracture, unspecified side, initial encounter for closed fracture
S02112B	Type III occipital condyle fracture, unspecified side, initial encounter for open fracture
S02113A	Unspecified occipital condyle fracture, initial encounter for closed fracture
S02113B	Unspecified occipital condyle fracture, initial encounter for open fracture
S02118A	Other fracture of occiput, unspecified side, initial encounter for closed fracture
S02118B	Other fracture of occiput, unspecified side, initial encounter for open fracture
S02119A	Unspecified fracture of occiput, initial encounter for closed fracture
S02119B	Unspecified fracture of occiput, initial encounter for open fracture
S0211AA	Type I occipital condyle fracture, right side, initial encounter for closed fracture
S0211AB	Type I occipital condyle fracture, right side, initial encounter for open fracture
S0211BA	Type I occipital condyle fracture, left side, initial encounter for closed fracture
S0211BB	Type I occipital condyle fracture, left side, initial encounter for open fracture
S0211CA	Type II occipital condyle fracture, right side, initial encounter for closed fracture
S0211CB	Type II occipital condyle fracture, right side, initial encounter for open fracture
S0211DA	Type II occipital condyle fracture, left side, initial encounter for closed fracture
S0211DB	Type II occipital condyle fracture, left side, initial encounter for open fracture
S0211EA	Type III occipital condyle fracture, right side, initial encounter for closed fracture
S0211EB	Type III occipital condyle fracture, right side, initial encounter for open fracture
S0211FA	Type III occipital condyle fracture, left side, initial encounter for closed fracture
S0211FB	Type III occipital condyle fracture, left side, initial encounter for open fracture

S0211GA	Other fracture of occiput, right side, initial encounter for closed fracture
S0211GB	Other fracture of occiput, right side, initial encounter for open fracture
S0211HA	Other fracture of occiput, left side, initial encounter for closed fracture
S0211HB	Other fracture of occiput, left side, initial encounter for open fracture
S0219XA	Other fracture of base of skull, initial encounter for closed fracture
S0219XB	Other fracture of base of skull, initial encounter for open fracture
S022XXA	Fracture of nasal bones, initial encounter for closed fracture
S022XXB	Fracture of nasal bones, initial encounter for open fracture
S0230XA	Fracture of orbital floor, unspecified side, initial encounter for closed fracture
S0230XB	Fracture of orbital floor, unspecified side, initial encounter for open fracture
S0231XA	Fracture of orbital floor, right side, initial encounter for closed fracture
S0231XB	Fracture of orbital floor, right side, initial encounter for open fracture
S0232XA	Fracture of orbital floor, left side, initial encounter for closed fracture
S0232XB	Fracture of orbital floor, left side, initial encounter for open fracture
S02400A	Malar fracture, unspecified side, initial encounter for closed fracture
S02400B	Malar fracture, unspecified side, initial encounter for open fracture
S02401A	Maxillary fracture, unspecified side, initial encounter for closed fracture
S02401B	Maxillary fracture, unspecified side, initial encounter for open fracture
S02402A	Zygomatic fracture, unspecified side, initial encounter for closed fracture
S02402B	Zygomatic fracture, unspecified side, initial encounter for open fracture
S0240AA	Malar fracture, right side, initial encounter for closed fracture
S0240AB	Malar fracture, right side, initial encounter for open fracture
S0240BA	Malar fracture, left side, initial encounter for closed fracture
S0240BB	Malar fracture, left side, initial encounter for open fracture
S0240CA	Maxillary fracture, right side, initial encounter for closed fracture
S0240CB	Maxillary fracture, right side, initial encounter for open fracture
S0240DA	Maxillary fracture, left side, initial encounter for closed fracture
S0240DB	Maxillary fracture, left side, initial encounter for open fracture
S0240EA	Zygomatic fracture, right side, initial encounter for closed fracture
S0240EB	Zygomatic fracture, right side, initial encounter for open fracture
S0240FA	Zygomatic fracture, left side, initial encounter for closed fracture
S0240FB	Zygomatic fracture, left side, initial encounter for open fracture
S02411A	LeFort I fracture, initial encounter for closed fracture
S02411B	LeFort I fracture, initial encounter for open fracture
S02412A	LeFort II fracture, initial encounter for closed fracture
S02412B	LeFort II fracture, initial encounter for open fracture

S02413A	LeFort III fracture, initial encounter for closed fracture
S02413B	LeFort III fracture, initial encounter for open fracture
S0242XA	Fracture of alveolus of maxilla, initial encounter for closed fracture
S0242XB	Fracture of alveolus of maxilla, initial encounter for open fracture
S02600A	Fracture of unspecified part of body of mandible, unspecified side, initial encounter for closed fracture
S02600B	Fracture of unspecified part of body of mandible, unspecified side, initial encounter for open fracture
S02601A	Fracture of unspecified part of body of right mandible, initial encounter for closed fracture
S02601B	Fracture of unspecified part of body of right mandible, initial encounter for open fracture
S02602A	Fracture of unspecified part of body of left mandible, initial encounter for closed fracture
S02602B	Fracture of unspecified part of body of left mandible, initial encounter for open fracture
S02609A	Fracture of mandible, unspecified, initial encounter for closed fracture
S02609B	Fracture of mandible, unspecified, initial encounter for open fracture
S02610A	Fracture of condylar process of mandible, unspecified side, initial encounter for closed fracture
S02610B	Fracture of condylar process of mandible, unspecified side, initial encounter for open fracture
S02611A	Fracture of condylar process of right mandible, initial encounter for closed fracture
S02611B	Fracture of condylar process of right mandible, initial encounter for open fracture
S02612A	Fracture of condylar process of left mandible, initial encounter for closed fracture
S02612B	Fracture of condylar process of left mandible, initial encounter for open fracture
S02620A	Fracture of subcondylar process of mandible, unspecified side, initial encounter for closed fracture
S02620B	Fracture of subcondylar process of mandible, unspecified side, initial encounter for open fracture
S02621A	Fracture of subcondylar process of right mandible, initial encounter for closed fracture
S02621B	Fracture of subcondylar process of right mandible, initial encounter for open fracture
S02622A	Fracture of subcondylar process of left mandible, initial encounter for closed fracture
S02622B	Fracture of subcondylar process of left mandible, initial encounter for open fracture
S02630A	Fracture of coronoid process of mandible, unspecified side, initial encounter for closed fracture
S02630B	Fracture of coronoid process of mandible, unspecified side, initial encounter for open fracture
S02631A	Fracture of coronoid process of right mandible, initial encounter for closed fracture
S02631B	Fracture of coronoid process of right mandible, initial encounter for open fracture
S02632A	Fracture of coronoid process of left mandible, initial encounter for closed fracture
S02632B	Fracture of coronoid process of left mandible, initial encounter for open fracture
S02640A	Fracture of ramus of mandible, unspecified side, initial encounter for closed fracture

S02640B	Fracture of ramus of mandible, unspecified side, initial encounter for open fracture
S02641A	Fracture of ramus of right mandible, initial encounter for closed fracture
S02641B	Fracture of ramus of right mandible, initial encounter for open fracture
S02642A	Fracture of ramus of left mandible, initial encounter for closed fracture
S02642B	Fracture of ramus of left mandible, initial encounter for open fracture
S02650A	Fracture of angle of mandible, unspecified side, initial encounter for closed fracture
S02650B	Fracture of angle of mandible, unspecified side, initial encounter for open fracture
S02651A	Fracture of angle of right mandible, initial encounter for closed fracture
S02651B	Fracture of angle of right mandible, initial encounter for open fracture
S02652A	Fracture of angle of left mandible, initial encounter for closed fracture
S02652B	Fracture of angle of left mandible, initial encounter for open fracture
S0266XA	Fracture of symphysis of mandible, initial encounter for closed fracture
S0266XB	Fracture of symphysis of mandible, initial encounter for open fracture
S02670A	Fracture of alveolus of mandible, unspecified side, initial encounter for closed fracture
S02670B	Fracture of alveolus of mandible, unspecified side, initial encounter for open fracture
S02671A	Fracture of alveolus of right mandible, initial encounter for closed fracture
S02671B	Fracture of alveolus of right mandible, initial encounter for open fracture
S02672A	Fracture of alveolus of left mandible, initial encounter for closed fracture
S02672B	Fracture of alveolus of left mandible, initial encounter for open fracture
S0269XA	Fracture of mandible of other specified site, initial encounter for closed fracture
S0269XB	Fracture of mandible of other specified site, initial encounter for open fracture
S0280XA	Fracture of other specified skull and facial bones, unspecified side, initial encounter for closed fracture
S0280XB	Fracture of other specified skull and facial bones, unspecified side, initial encounter for open fracture
S0281XA	Fracture of other specified skull and facial bones, right side, initial encounter for closed fracture
S0281XB	Fracture of other specified skull and facial bones, right side, initial encounter for open fracture
S0282XA	Fracture of other specified skull and facial bones, left side, initial encounter for closed fracture
S0282XB	Fracture of other specified skull and facial bones, left side, initial encounter for open fracture
S0291XA	Unspecified fracture of skull, initial encounter for closed fracture
S0291XB	Unspecified fracture of skull, initial encounter for open fracture
S0292XA	Unspecified fracture of facial bones, initial encounter for closed fracture
S0292XB	Unspecified fracture of facial bones, initial encounter for open fracture
S060X0A	Concussion without loss of consciousness, initial encounter
S060X1A	Concussion with loss of consciousness of 30 minutes or less, initial encounter

S060X9A	Concussion with loss of consciousness of unspecified duration, initial encounter
S061X0A	Traumatic cerebral edema without loss of consciousness, initial encounter
S061X1A	Traumatic cerebral edema with loss of consciousness of 30 minutes or less, initial encounter
S061X2A	Traumatic cerebral edema with loss of consciousness of 31 minutes to 59 minutes, initial encounter
S061X3A	Traumatic cerebral edema with loss of consciousness of 1 hour to 5 hours 59 minutes, initial encounter
S061X4A	Traumatic cerebral edema with loss of consciousness of 6 hours to 24 hours, initial encounter
S061X5A	Traumatic cerebral edema with loss of consciousness greater than 24 hours with return to pre-existing conscious level, initial encounter
S061X6A	Traumatic cerebral edema with loss of consciousness greater than 24 hours without return to pre-existing conscious level with patient surviving, initial encounter
S061X7	Traumatic cerebral edema with loss of consciousness of any duration with death due to brain injury prior to regaining consciousness
S061X7A	Traumatic cerebral edema with loss of consciousness of any duration with death due to brain injury prior to regaining consciousness, initial encounter
S061X8	Traumatic cerebral edema with loss of consciousness of any duration with death due to other cause prior to regaining consciousness
S061X8A	Traumatic cerebral edema with loss of consciousness of any duration with death due to other cause prior to regaining consciousness, initial encounter
S061X9A	Traumatic cerebral edema with loss of consciousness of unspecified duration, initial encounter
S062X0A	Diffuse traumatic brain injury without loss of consciousness, initial encounter
S062X1A	Diffuse traumatic brain injury with loss of consciousness of 30 minutes or less, initial encounter
S062X2A	Diffuse traumatic brain injury with loss of consciousness of 31 minutes to 59 minutes, initial encounter
S062X3A	Diffuse traumatic brain injury with loss of consciousness of 1 hour to 5 hours 59 minutes, initial encounter
S062X4A	Diffuse traumatic brain injury with loss of consciousness of 6 hours to 24 hours, initial encounter
S062X5A	Diffuse traumatic brain injury with loss of consciousness greater than 24 hours with return to pre-existing conscious levels, initial encounter
S062X6A	Diffuse traumatic brain injury with loss of consciousness greater than 24 hours without return to pre-existing conscious level with patient surviving, initial encounter
S062X7	Diffuse traumatic brain injury with loss of consciousness of any duration with death due to brain injury prior to regaining consciousness
S062X7A	Diffuse traumatic brain injury with loss of consciousness of any duration with death due to brain injury prior to regaining consciousness, initial encounter
S062X8	Diffuse traumatic brain injury with loss of consciousness of any duration with death due to other cause prior to regaining consciousness
S062X8A	Diffuse traumatic brain injury with loss of consciousness of any duration with death due to other cause prior to regaining consciousness, initial encounter
S062X9A	Diffuse traumatic brain injury with loss of consciousness of unspecified duration, initial

	encounter
S06300A	Unspecified focal traumatic brain injury without loss of consciousness, initial encounter
S06301A	Unspecified focal traumatic brain injury with loss of consciousness of 30 minutes or less, initial encounter
S06302A	Unspecified focal traumatic brain injury with loss of consciousness of 31 minutes to 59 minutes, initial encounter
S06303A	Unspecified focal traumatic brain injury with loss of consciousness of 1 hour to 5 hours 59 minutes, initial encounter
S06304A	Unspecified focal traumatic brain injury with loss of consciousness of 6 hours to 24 hours, initial encounter
S06305A	Unspecified focal traumatic brain injury with loss of consciousness greater than 24 hours with return to pre-existing conscious level, initial encounter
S06306A	Unspecified focal traumatic brain injury with loss of consciousness greater than 24 hours without return to pre-existing conscious level with patient surviving, initial encounter
S06307	Unspecified focal traumatic brain injury with loss of consciousness of any duration with death due to brain injury prior to regaining consciousness
S06307A	Unspecified focal traumatic brain injury with loss of consciousness of any duration with death due to brain injury prior to regaining consciousness, initial encounter
S06308	Unspecified focal traumatic brain injury with loss of consciousness of any duration with death due to other cause prior to regaining consciousness
S06308A	Unspecified focal traumatic brain injury with loss of consciousness of any duration with death due to other cause prior to regaining consciousness, initial encounter
S06309A	Unspecified focal traumatic brain injury with loss of consciousness of unspecified duration, initial encounter
S06310A	Contusion and laceration of right cerebrum without loss of consciousness
S06311A	Contusion and laceration of right cerebrum with loss of consciousness of 30 minutes or less, initial encounter
S06312A	Contusion and laceration of right cerebrum with loss of consciousness of 31 minutes to 59 minutes, initial encounter
S06313A	Contusion and laceration of right cerebrum with loss of consciousness of 1 hour to 5 hours 59 minutes, initial encounter
S06314A	Contusion and laceration of right cerebrum with loss of consciousness of 6 hours to 24 hours, initial encounter
S06315A	Contusion and laceration of right cerebrum with loss of consciousness greater than 24 hours with return to pre-existing conscious level, initial encounter
S06316A	Contusion and laceration of right cerebrum with loss of consciousness greater than 24 hours without return to pre-existing conscious level with patient surviving, initial encounter
S06317	Contusion and laceration of right cerebrum with loss of consciousness of any duration with death due to brain injury prior to regaining consciousness
S06317A	Contusion and laceration of right cerebrum with loss of consciousness of any duration with death due to brain injury prior to regaining consciousness, initial encounter
S06318	Contusion and laceration of right cerebrum with loss of consciousness of any duration with death due to other cause prior to regaining consciousness
S06318A	Contusion and laceration of right cerebrum with loss of consciousness of any duration with death due to other cause prior to regaining consciousness, initial encounter

S06319A	Contusion and laceration of right cerebrum with loss of consciousness of unspecified duration, initial encounter
S06320A	Contusion and laceration of left cerebrum without loss of consciousness, initial encounter
S06321A	Contusion and laceration of left cerebrum with loss of consciousness of 30 minutes or less, initial encounter
S06322A	Contusion and laceration of left cerebrum with loss of consciousness of 31 minutes to 59 minutes, initial encounter
S06323A	Contusion and laceration of left cerebrum with loss of consciousness of 1 hour to 5 hours 59 minutes, initial encounter
S06324A	Contusion and laceration of left cerebrum with loss of consciousness of 6 hours to 24 hours, initial encounter
S06325A	Contusion and laceration of left cerebrum with loss of consciousness greater than 24 hours with return to pre-existing conscious level, initial encounter
S06326A	Contusion and laceration of left cerebrum with loss of consciousness greater than 24 hours without return to pre-existing conscious level with patient surviving, initial encounter
S06327	Contusion and laceration of left cerebrum with loss of consciousness of any duration with death due to brain injury prior to regaining consciousness
S06327A	Contusion and laceration of left cerebrum with loss of consciousness of any duration with death due to brain injury prior to regaining consciousness, initial encounter
S06328	Contusion and laceration of left cerebrum with loss of consciousness of any duration with death due to other cause prior to regaining consciousness
S06328A	Contusion and laceration of left cerebrum with loss of consciousness of any duration with death due to other cause prior to regaining consciousness, initial encounter
S06329A	Contusion and laceration of left cerebrum with loss of consciousness of unspecified duration, initial encounter
S06330A	Contusion and laceration of cerebrum, unspecified, without loss of consciousness, initial encounter
S06331A	Contusion and laceration of cerebrum, unspecified, with loss of consciousness of 30 minutes or less, initial encounter
S06332A	Contusion and laceration of cerebrum, unspecified, with loss of consciousness of 31 minutes to 59 minutes, initial encounter
S06333A	Contusion and laceration of cerebrum, unspecified, with loss of consciousness of 1 hour to 5 hours 59 minutes, initial encounter
S06334A	Contusion and laceration of cerebrum, unspecified, with loss of consciousness of 6 hours to 24 hours, initial encounter
S06335A	Contusion and laceration of cerebrum, unspecified, with loss of consciousness greater than 24 hours with return to pre-existing conscious level, initial encounter
S06336A	Contusion and laceration of cerebrum, unspecified, with loss of consciousness greater than 24 hours without return to pre-existing conscious level with patient surviving, initial encounter
S06337	Contusion and laceration of cerebrum, unspecified, with loss of consciousness of any duration with death due to brain injury prior to regaining consciousness
S06337A	Contusion and laceration of cerebrum, unspecified, with loss of consciousness of any duration with death due to brain injury prior to regaining consciousness, initial encounter
S06338	Contusion and laceration of cerebrum, unspecified, with loss of consciousness of any duration with death due to other cause prior to regaining consciousness

S06338A	Contusion and laceration of cerebrum, unspecified, with loss of consciousness of any duration with death due to other cause prior to regaining consciousness, initial encounter
S06339A	Contusion and laceration of cerebrum, unspecified, with loss of consciousness of unspecified duration, initial encounter
S06340A	Traumatic hemorrhage of right cerebrum without loss of consciousness, initial encounter
S06341A	Traumatic hemorrhage of right cerebrum with loss of consciousness of 30 minutes or less, initial encounter
S06342A	Traumatic hemorrhage of right cerebrum with loss of consciousness of 31 minutes to 59 minutes, initial encounter
S06343A	Traumatic hemorrhage of right cerebrum with loss of consciousness of 1 hours to 5 hours 59 minutes, initial encounter
S06344A	Traumatic hemorrhage of right cerebrum with loss of consciousness of 6 hours to 24 hours, initial encounter
S06345A	Traumatic hemorrhage of right cerebrum with loss of consciousness greater than 24 hours with return to pre-existing conscious level, initial encounter
S06346A	Traumatic hemorrhage of right cerebrum with loss of consciousness greater than 24 hours without return to pre-existing conscious level with patient surviving, initial encounter
S06347	Traumatic hemorrhage of right cerebrum with loss of consciousness of any duration with death due to brain injury prior to regaining consciousness
S06347A	Traumatic hemorrhage of right cerebrum with loss of consciousness of any duration with death due to brain injury prior to regaining consciousness, initial encounter
S06348	Traumatic hemorrhage of right cerebrum with loss of consciousness of any duration with death due to other cause prior to regaining consciousness
S06348A	Traumatic hemorrhage of right cerebrum with loss of consciousness of any duration with death due to other cause prior to regaining consciousness, initial encounter
S06349A	Traumatic hemorrhage of right cerebrum with loss of consciousness of unspecified duration, initial encounter
S06350A	Traumatic hemorrhage of left cerebrum without loss of consciousness, initial encounter
S06351A	Traumatic hemorrhage of left cerebrum with loss of consciousness of 30 minutes or less, initial encounter
S06352A	Traumatic hemorrhage of left cerebrum with loss of consciousness of 31 minutes to 59 minutes, initial encounter
S06353A	Traumatic hemorrhage of left cerebrum with loss of consciousness of 1 hours to 5 hours 59 minutes, initial encounter
S06354A	Traumatic hemorrhage of left cerebrum with loss of consciousness of 6 hours to 24 hours, initial encounter
S06355A	Traumatic hemorrhage of left cerebrum with loss of consciousness greater than 24 hours with return to pre-existing conscious level, initial encounter
S06356A	Traumatic hemorrhage of left cerebrum with loss of consciousness greater than 24 hours without return to pre-existing conscious level with patient surviving, initial encounter
S06357	Traumatic hemorrhage of left cerebrum with loss of consciousness of any duration with death due to brain injury prior to regaining consciousness
S06357A	Traumatic hemorrhage of left cerebrum with loss of consciousness of any duration with death due to brain injury prior to regaining consciousness, initial encounter
S06358	Traumatic hemorrhage of left cerebrum with loss of consciousness of any duration with

	death due to other cause prior to regaining consciousness
S06358A	Traumatic hemorrhage of left cerebrum with loss of consciousness of any duration with death due to other cause prior to regaining consciousness, initial encounter
S06359A	Traumatic hemorrhage of left cerebrum with loss of consciousness of unspecified duration, initial encounter
S06360A	Traumatic hemorrhage of cerebrum, unspecified, without loss of consciousness, initial encounter
S06361A	Traumatic hemorrhage of cerebrum, unspecified, with loss of consciousness of 30 minutes or less, initial encounter
S06362A	Traumatic hemorrhage of cerebrum, unspecified, with loss of consciousness of 31 minutes to 59 minutes, initial encounter
S06363A	Traumatic hemorrhage of cerebrum, unspecified, with loss of consciousness of 1 hours to 5 hours 59 minutes, initial encounter
S06364A	Traumatic hemorrhage of cerebrum, unspecified, with loss of consciousness of 6 hours to 24 hours, initial encounter
S06365A	Traumatic hemorrhage of cerebrum, unspecified, with loss of consciousness greater than 24 hours with return to pre-existing conscious level, initial encounter
S06366A	Traumatic hemorrhage of cerebrum, unspecified, with loss of consciousness greater than 24 hours without return to pre-existing conscious level with patient surviving, initial encounter
S06367	Traumatic hemorrhage of cerebrum, unspecified, with loss of consciousness of any duration with death due to brain injury prior to regaining consciousness
S06367A	Traumatic hemorrhage of cerebrum, unspecified, with loss of consciousness of any duration with death due to brain injury prior to regaining consciousness, initial encounter
S06368	Traumatic hemorrhage of cerebrum, unspecified, with loss of consciousness of any duration with death due to other cause prior to regaining consciousness
S06368A	Traumatic hemorrhage of cerebrum, unspecified, with loss of consciousness of any duration with death due to other cause prior to regaining consciousness, initial encounter
S06369A	Traumatic hemorrhage of cerebrum, unspecified, with loss of consciousness of unspecified duration, initial encounter
S06370A	Contusion, laceration, and hemorrhage of cerebellum without loss of consciousness, initial encounter
S06371A	Contusion, laceration, and hemorrhage of cerebellum with loss of consciousness of 30 minutes or less, initial encounter
S06372A	Contusion, laceration, and hemorrhage of cerebellum with loss of consciousness of 31 minutes to 59 minutes, initial encounter
S06373A	Contusion, laceration, and hemorrhage of cerebellum with loss of consciousness of 1 hour to 5 hours 59 minutes, initial encounter
S06374A	Contusion, laceration, and hemorrhage of cerebellum with loss of consciousness of 6 hours to 24 hours, initial encounter
S06375A	Contusion, laceration, and hemorrhage of cerebellum with loss of consciousness greater than 24 hours with return to pre-existing conscious level, initial encounter
S06376A	Contusion, laceration, and hemorrhage of cerebellum with loss of consciousness greater than 24 hours without return to pre-existing conscious level with patient surviving, initial encounter
S06377	Contusion, laceration, and hemorrhage of cerebellum with loss of consciousness of any duration with death due to brain injury prior to regaining consciousness

S06377A	Contusion, laceration, and hemorrhage of cerebellum with loss of consciousness of any duration with death due to brain injury prior to regaining consciousness, initial encounter
S06378	Contusion, laceration, and hemorrhage of cerebellum with loss of consciousness of any duration with death due to other cause prior to regaining consciousness
S06378A	Contusion, laceration, and hemorrhage of cerebellum with loss of consciousness of any duration with death due to other cause prior to regaining consciousness, initial encounter
S06379A	Contusion, laceration, and hemorrhage of cerebellum with loss of consciousness of unspecified duration, initial encounter
S06380A	Contusion, laceration, and hemorrhage of brainstem without loss of consciousness, initial encounter
S06381A	Contusion, laceration, and hemorrhage of brainstem with loss of consciousness of 30 minutes or less, initial encounter
S06382A	Contusion, laceration, and hemorrhage of brainstem with loss of consciousness of 31 minutes to 59 minutes, initial encounter
S06383A	Contusion, laceration, and hemorrhage of brainstem with loss of consciousness of 1 hour to 5 hours 59 minutes, initial encounter
S06384A	Contusion, laceration, and hemorrhage of brainstem with loss of consciousness of 6 hours to 24 hours, initial encounter
S06385A	Contusion, laceration, and hemorrhage of brainstem with loss of consciousness greater than 24 hours with return to pre-existing conscious level, initial encounter
S06386A	Contusion, laceration, and hemorrhage of brainstem with loss of consciousness greater than 24 hours without return to pre-existing conscious level with patient surviving, initial encounter
S06387	Contusion, laceration, and hemorrhage of brainstem with loss of consciousness of any duration with death due to brain injury prior to regaining consciousness
S06387A	Contusion, laceration, and hemorrhage of brainstem with loss of consciousness of any duration with death due to brain injury prior to regaining consciousness, initial encounter
S06388	Contusion, laceration, and hemorrhage of brainstem with loss of consciousness of any duration with death due to other cause prior to regaining consciousness
S06388A	Contusion, laceration, and hemorrhage of brainstem with loss of consciousness of any duration with death due to other cause prior to regaining consciousness, initial encounter
S06389A	Contusion, laceration, and hemorrhage of brainstem with loss of consciousness of unspecified duration, initial encounter
S064X0A	Epidural hemorrhage without loss of consciousness, initial encounter
S064X1A	Epidural hemorrhage with loss of consciousness of 30 minutes or less, initial encounter
S064X2A	Epidural hemorrhage with loss of consciousness of 31 minutes to 59 minutes, initial encounter
S064X3A	Epidural hemorrhage with loss of consciousness of 1 hour to 5 hours 59 minutes, initial encounter
S064X4A	Epidural hemorrhage with loss of consciousness of 6 hours to 24 hours, initial encounter
S064X5A	Epidural hemorrhage with loss of consciousness greater than 24 hours with return to pre-existing conscious level, initial encounter
S064X6A	Epidural hemorrhage with loss of consciousness greater than 24 hours without return to pre-existing conscious level with patient surviving, initial encounter
S064X7	Epidural hemorrhage with loss of consciousness of any duration with death due to brain injury prior to regaining consciousness

S064X7A	Epidural hemorrhage with loss of consciousness of any duration with death due to brain injury prior to regaining consciousness, initial encounter
S064X8	Epidural hemorrhage with loss of consciousness of any duration with death due to other causes prior to regaining consciousness
S064X8A	Epidural hemorrhage with loss of consciousness of any duration with death due to other causes prior to regaining consciousness, initial encounter
S064X9A	Epidural hemorrhage with loss of consciousness of unspecified duration, initial encounter
S065X0A	Traumatic subdural hemorrhage without loss of consciousness, initial encounter
S065X1A	Traumatic subdural hemorrhage with loss of consciousness of 30 minutes or less, initial encounter
S065X2A	Traumatic subdural hemorrhage with loss of consciousness of 31 minutes to 59 minutes, initial encounter
S065X3A	Traumatic subdural hemorrhage with loss of consciousness of 1 hour to 5 hours 59 minutes, initial encounter
S065X4A	Traumatic subdural hemorrhage with loss of consciousness of 6 hours to 24 hours, initial encounter
S065X5A	Traumatic subdural hemorrhage with loss of consciousness greater than 24 hours with return to pre-existing conscious level, initial encounter
S065X6A	Traumatic subdural hemorrhage with loss of consciousness greater than 24 hours without return to pre-existing conscious level with patient surviving, initial encounter
S065X7	Traumatic subdural hemorrhage with loss of consciousness of any duration with death due to brain injury before regaining consciousness
S065X7A	Traumatic subdural hemorrhage with loss of consciousness of any duration with death due to brain injury before regaining consciousness, initial encounter
S065X8	Traumatic subdural hemorrhage with loss of consciousness of any duration with death due to other cause before regaining consciousness
S065X8A	Traumatic subdural hemorrhage with loss of consciousness of any duration with death due to other cause before regaining consciousness, initial encounter
S065X9A	Traumatic subdural hemorrhage with loss of consciousness of unspecified duration, initial encounter
S066X0A	Traumatic subarachnoid hemorrhage without loss of consciousness, initial encounter
S066X1A	Traumatic subarachnoid hemorrhage with loss of consciousness of 30 minutes or less, initial encounter
S066X2A	Traumatic subarachnoid hemorrhage with loss of consciousness of 31 minutes to 59 minutes, initial encounter
S066X3A	Traumatic subarachnoid hemorrhage with loss of consciousness of 1 hour to 5 hours 59 minutes, initial encounter
S066X4A	Traumatic subarachnoid hemorrhage with loss of consciousness of 6 hours to 24 hours, initial encounter
S066X5A	Traumatic subarachnoid hemorrhage with loss of consciousness greater than 24 hours with return to pre-existing conscious level, initial encounter
S066X6A	Traumatic subarachnoid hemorrhage with loss of consciousness greater than 24 hours without return to pre-existing conscious level with patient surviving, initial encounter
S066X7	Traumatic subarachnoid hemorrhage with loss of consciousness of any duration with death due to brain injury prior to regaining consciousness
S066X7A	Traumatic subarachnoid hemorrhage with loss of consciousness of any duration with

	death due to brain injury prior to regaining consciousness, initial encounter
S066X8	Traumatic subarachnoid hemorrhage with loss of consciousness of any duration with death due to other cause prior to regaining consciousness
S066X8A	Traumatic subarachnoid hemorrhage with loss of consciousness of any duration with death due to other cause prior to regaining consciousness, initial encounter
S066X9A	Traumatic subarachnoid hemorrhage with loss of consciousness of unspecified duration, initial encounter
S06810A	Injury of right internal carotid artery, intracranial portion, not elsewhere classified without loss of consciousness, initial encounter
S06811A	Injury of right internal carotid artery, intracranial portion, not elsewhere classified with loss of consciousness of 30 minutes or less, initial encounter
S06812A	Injury of right internal carotid artery, intracranial portion, not elsewhere classified with loss of consciousness of 31 minutes to 59 minutes, initial encounter
S06813A	Injury of right internal carotid artery, intracranial portion, not elsewhere classified with loss of consciousness of 1 hour to 5 hours 59 minutes, initial encounter
S06814A	Injury of right internal carotid artery, intracranial portion, not elsewhere classified with loss of consciousness of 6 hours to 24 hours, initial encounter
S06815A	Injury of right internal carotid artery, intracranial portion, not elsewhere classified with loss of consciousness greater than 24 hours with return to pre-existing conscious level, initial encounter
S06816A	Injury of right internal carotid artery, intracranial portion, not elsewhere classified with loss of consciousness greater than 24 hours without return to pre-existing conscious level with patient surviving, initial encounter
S06817	Injury of right internal carotid artery, intracranial portion, not elsewhere classified with loss of consciousness of any duration with death due to brain injury prior to regaining consciousness
S06817A	Injury of right internal carotid artery, intracranial portion, not elsewhere classified with loss of consciousness of any duration with death due to brain injury prior to regaining consciousness, initial encounter
S06818	Injury of right internal carotid artery, intracranial portion, not elsewhere classified with loss of consciousness of any duration with death due to other cause prior to regaining consciousness
S06818A	Injury of right internal carotid artery, intracranial portion, not elsewhere classified with loss of consciousness of any duration with death due to other cause prior to regaining consciousness, initial encounter
S06819A	Injury of right internal carotid artery, intracranial portion, not elsewhere classified with loss of consciousness of unspecified duration, initial encounter
S06820A	Injury of left internal carotid artery, intracranial portion, not elsewhere classified without loss of consciousness, initial encounter
S06821A	Injury of left internal carotid artery, intracranial portion, not elsewhere classified with loss of consciousness of 30 minutes or less, initial encounter
S06822A	Injury of left internal carotid artery, intracranial portion, not elsewhere classified with loss of consciousness of 31 minutes to 59 minutes, initial encounter
S06823A	Injury of left internal carotid artery, intracranial portion, not elsewhere classified with loss of consciousness of 1 hour to 5 hours 59 minutes, initial encounter
S06824A	Injury of left internal carotid artery, intracranial portion, not elsewhere classified with loss of consciousness of 6 hours to 24 hours, initial encounter

S06825A	Injury of left internal carotid artery, intracranial portion, not elsewhere classified with loss of consciousness greater than 24 hours with return to pre-existing conscious level, initial encounter
S06826A	Injury of left internal carotid artery, intracranial portion, not elsewhere classified with loss of consciousness greater than 24 hours without return to pre-existing conscious level with patient surviving, initial encounter
S06827	Injury of left internal carotid artery, intracranial portion, not elsewhere classified with loss of consciousness of any duration with death due to brain injury prior to regaining consciousness
S06827A	Injury of left internal carotid artery, intracranial portion, not elsewhere classified with loss of consciousness of any duration with death due to brain injury prior to regaining consciousness, initial encounter
S06828	Injury of left internal carotid artery, intracranial portion, not elsewhere classified with loss of consciousness of any duration with death due to other cause prior to regaining consciousness
S06828A	Injury of left internal carotid artery, intracranial portion, not elsewhere classified with loss of consciousness of any duration with death due to other cause prior to regaining consciousness, initial encounter
S06829A	Injury of left internal carotid artery, intracranial portion, not elsewhere classified with loss of consciousness of unspecified duration, initial encounter
S06890A	Other specified intracranial injury without loss of consciousness, initial encounter
S06891A	Other specified intracranial injury with loss of consciousness of 30 minutes or less, initial encounter
S06892A	Other specified intracranial injury with loss of consciousness of 31 minutes to 59 minutes, initial encounter
S06893A	Other specified intracranial injury with loss of consciousness of 1 hour to 5 hours 59 minutes, initial encounter
S06894A	Other specified intracranial injury with loss of consciousness of 6 hours to 24 hours, initial encounter
S06895A	Other specified intracranial injury with loss of consciousness greater than 24 hours with return to pre-existing conscious level, initial encounter
S06896A	Other specified intracranial injury with loss of consciousness greater than 24 hours without return to pre-existing conscious level with patient surviving, initial encounter
S06897	Other specified intracranial injury with loss of consciousness of any duration with death due to brain injury prior to regaining consciousness
S06897A	Other specified intracranial injury with loss of consciousness of any duration with death due to brain injury prior to regaining consciousness, initial encounter
S06898	Other specified intracranial injury with loss of consciousness of any duration with death due to other cause prior to regaining consciousness
S06898A	Other specified intracranial injury with loss of consciousness of any duration with death due to other cause prior to regaining consciousness, initial encounter
S06899A	Other specified intracranial injury with loss of consciousness of unspecified duration, initial encounter
S069X0A	Unspecified intracranial injury without loss of consciousness, initial encounter
S069X1A	Unspecified intracranial injury with loss of consciousness of 30 minutes or less, initial encounter

S069X2A	Unspecified intracranial injury with loss of consciousness of 31 minutes to 59 minutes, initial encounter
S069X3A	Unspecified intracranial injury with loss of consciousness of 1 hour to 5 hours 59 minutes, initial encounter
S069X4A	Unspecified intracranial injury with loss of consciousness of 6 hours to 24 hours, initial encounter
S069X5A	Unspecified intracranial injury with loss of consciousness greater than 24 hours with return to pre-existing conscious level, initial encounter
S069X6A	Unspecified intracranial injury with loss of consciousness greater than 24 hours without return to pre-existing conscious level with patient surviving, initial encounter
S069X7	Unspecified intracranial injury with loss of consciousness of any duration with death due to brain injury prior to regaining consciousness
S069X7A	Unspecified intracranial injury with loss of consciousness of any duration with death due to brain injury prior to regaining consciousness, initial encounter
S069X8	Unspecified intracranial injury with loss of consciousness of any duration with death due to other cause prior to regaining consciousness
S069X8A	Unspecified intracranial injury with loss of consciousness of any duration with death due to other cause prior to regaining consciousness, initial encounter
S069X9A	Unspecified intracranial injury with loss of consciousness of unspecified duration, initial encounter