Combined use of Rotational and excimer lASER coronary atherectomy (RASER) during complex coronary angioplasty – an analysis of cases (2006-2016) from the British Cardiovascular Intervention Society database

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Abstract (221 words)

Introduction: Combining rotational (RA) and excimer laser coronary atherectomy (ELCA) - RASER atherectomy - is technique utilised in the percutaneous management of calcific coronary disease. The evidence base examining its safety and utility is sparse and limited to small case-series. This study examines the patterns and outcomes of RASER atherectomy use in the largest cohort to date.

Methods: Using the British Cardiac Intervention Society database, data were analysed on all PCI procedures in the UK between 2006-2016. Descriptive statistics and multivariate logistic regressions were used to examine baseline, procedural and outcome associations with RASER.

Results: We identified 153 (0.02%) RASER atherectomy cases out of 686,358 PCI procedures. Baseline covariates associated with RASER use were age, BMI, diabetes, stable coronary disease and previous CABG. Procedural co-variates associated with RASER were CTO-PCI, the use of more/longer stents, intravascular imaging, cutting balloons and microcatheters. Adjusted rates of in-hospital major adverse cardiac/cerebrovascular events (MACCE) were not significantly different with RASER. However, there were higher odds of arterial complications (OR 3.23, 95% CI: 1.58-6.61), slow flow (OR 3.50, 95% CI: 1.29-9.55) and shock induction (OR 9.66, 95% CI: 3.44-27.06).

Conclusions: RASER atherectomy use in complex PCI is associated with higher risk baseline and procedural characteristics. Although increased rates of shock induction, slow flow and arterial complications were observed, RASER does not increase the likelihood of in-hospital MACCE, major bleeding or death.

WHAT IS KNOWN:

- The combined use of rotational (RA) and excimer laser coronary atherectomy (ELCA) has been termed 'RASER'
- RASER is a technique for managing the most complex calcified coronary lesions which are non-crossable/non-dilatable during percutaneous coronary intervention (PCI)
- However, data on its efficacy and safety are limited to small published series.

WHAT THE STUDY ADDS:

- In a national database, RASER use during complex PCI was associated with higher risk baseline and procedural characteristics.
- After adjusting for baseline comorbid and procedural burden, RASER use did not increase in the likelihood of in-hospital MACCE, major bleeding or death.

INTRODUCTION

The combined use of rotational (RA) and excimer laser coronary atherectomy (ELCA) for managing heavily calcified coronary lesions has been termed 'RASER'[1]. This niche technique has been described to be particularly useful in managing non-crossable, non-dilatable calcified coronary stenosis. The rationale behind it is to use ELCA to modify the non-crossable lesion to create a large enough channel through which the 0.009-inch dedicated RA wire (Rotawire™) can then be delivered into the distal coronary vessel to facilitate rotational atherectomy [1].

The RASER combination of atherectomy devices has been described in the literature since 2010 for the management of calcified coronary disease[2]. This coincided with the increasing uptake and experience gained with the use of ELCA[3,4]. Subsequent case reports and small series of its use in the literature have suggested reasonable efficacy and safety in complex calcified coronary disease including chronic total occlusions (CTO) [2,5-8]. However, these small case series are likely to be subject to publication bias and thus, the evidence base for the actual safety and outcomes of RASER atherectomy remains uncertain. Therefore, we utilised the British Cardiovascular Intervention Society (BCIS) National PCI database to examine an eleven year period to study patterns associated with use of RASER and its periprocedural outcomes after adjusting for comorbid and procedural burden.

METHODS

Study design, setting and participants

We retrospectively analysed national data from all patients undergoing PCI in the United Kingdom between January 2006 and December 2016. During the study period, a total of 686,358 cases underwent PCI and were eligible for inclusion (See Supplementary Figure S1). Patients were excluded if ELCA or RA status was not recorded. The study design was approved by the review board of the National Institute of Clinical Outcomes Research (NICOR) and data release approved by the Healthcare Quality Improvement Partnership (HQIP).

Setting, data source, and study size

Data on PCI practice in the United Kingdom were obtained from the National PCI Audit dataset that records this information prospectively and publishes this information in the public domain as part of the national transparency agenda[9]. The data collection process is overseen by NICOR (http://www.ucl.ac.uk/nicor/) with high levels of case ascertainment. The database contains 121 clinical, procedural and outcomes variables, and in 2014, 98.6% of all PCI procedures performed in the National Health Service hospitals in the United Kingdom (www.bcis.org.uk/) were recorded on the database with approximately 100,000 new records currently added each year. The accuracy of and quality of the BCIS dataset has previously been ascertained[10].

Entry of all PCI procedures by UK interventional operators is mandated as part of professional revalidation. The participants of the database are tracked by the Medical Research Information Services for subsequent mortality using the patients' National Health Service (NHS) number (a unique identifier for any person registered within the NHS in England and Wales).

Study definitions

We analysed all recorded PCI procedures that were undertaken in the United Kingdom between January 1st, 2006 and December 31st, 2016. Study definitions were used as in the National PCI database. Specifically, pre-procedural renal failure is defined as any one of the following: creatinine >200µmol/l, renal transplant history, or dialysis. Pre- or post-PCI disease severity was defined as a stenosis ≥50% in the case of the left main artery. Intravascular imaging was a combination of intravascular ultrasound and optical coherence tomography. An access site complication was defined as either a false aneurysm, haemorrhage (without haematoma), haemorrhage with delayed hospital-discharge, retroperitoneal haematoma, arterial dissection, or any access site complication requiring surgical repair. The clinical outcomes examined were in-hospital mortality, in-hospital MACCE (defined as a combination death, peri-procedural ischaemic stroke, or peri-procedural myocardial infarction after PCI), in-hospital major bleeding (defined as either gastrointestinal bleed, intra-cerebral bleed, retroperitoneal haematoma, blood or platelet transfusion, access site haemorrhage, or an arterial access site complication requiring surgery), in-hospital emergency cardiac surgery, tamponade, side branch loss, dissection, perforation, heart block, slow flow, peri-procedural shock and arterial complications.

Data analyses

The study flow is illustrated in Supplementary Figure S1. Statistical analysis was performed using the R coding environment (Open Source). Multiple imputations were carried out using the *mice* package to reduce the potential bias from missing data (Supplementary Table S1), assuming missingness at random mechanisms. We used chained equations to impute the data for all variables with missing information and generated 5 datasets to be used in the analyses. We examined the baseline and procedural characteristics of participants by RASER status. We explored crude baseline comorbidities using a Chi-squared test for categorical variables and the Wilcoxon-Mann-Whitney test for continuous variables.

A multiple logistic regression model was developed to identify variables associated with RASER. The potential predictor baseline variables in the model were age, body mass index (BMI), female sex, cardiogenic shock pre-procedure, prior myocardial infarction (MI), prior coronary artery bypass grafting (CABG), prior PCI, diabetes mellitus, left main stem (LMS) stenosis, smoking history, history of renal disease, Canadian Cardiovascular Society score (CCS) >3, New York Heart Association score (NYHA) >3, previous stroke, peripheral vascular disease, hypertension, ejection fraction (EF) less than 30%, valvular heart disease, stable coronary disease, numbers of vessels/lesions attempted, chronic total occlusion (CTO) PCI, last remaining vessel (LRV) PCI, graft PCI, in-stent restenosis PCI, LMS PCI, left anterior descending (LAD) PCI, circumflex (Cx) PCI and right coronary artery (RCA) PCI.

To examine the influence of RASER on PCI outcomes, we built on and included the previously described baseline model to investigate the independent odds of in-hospital MACCE, in-hospital major bleeding, in-hospital death, peri-procedural MI, post-procedural stroke, arterial complications, acute kidney injury, DC cardioversion, coronary dissection, emergency CABG, gastrointestinal bleeding, heart block, perforation, post-PCI coronary disease, shock induction, side branch loss, slow flow, pericardial tamponade, transfusion.

RESULTS

Utility of RASER and baseline demographics of study population

Crude numbers per year of RASER-PCI increased during the initial study period from 0 in 2006 to 26 in 2013, forming a rising proportion in relation to all PCI (0.00% in 2006 to 0.04% in 2013), followed by a plateau and subsequent drop in use in 2015/2016 (0.02% in 2015, 0.03% in 2016, Figure 1A/B). The baseline characteristics of PCI patients with and without RASER use are presented in Table 1. RASER use was associated with increasing age, higher BMI, previous MI, previous CABG, previous PCI, diabetes mellitus, ejection fraction <30%, LMS disease pre-PCI, renal disease, NYHA >3, stroke, peripheral vascular disease, hypertension, valvular heart disease and stable coronary disease (p <0.05, unadjusted).

Procedural variables during PCI by RASER use

Procedural variables for PCI patients with and without RASER use are presented in Table 2. PCI cases when RASER was used were associated with a higher number of lesions and CTO attempted, use of more and longer stents, more successful lesions, shorter hospital stay, more dual access, lower utility of GPIIbIIIa inhibitors, more intravascular imaging, more cutting balloon and microcatheter use, more last remaining vessel (LRV), LMS and RCA PCI, but less LAD PCI (p <0.05, unadjusted).

Adjusted co-variates associated with RASER use during PCI in England and Wales 2006-2016

After adjusting for baseline comorbidities and procedural variables using a multivariate analysis, several factors remained significantly associated with RASER use (Figure 2). Graft PCI was less likely to be associated with RASER use, whereas higher BMI, older patients, number of lesions attempted, diabetes, hypertension, previous CABG, stable coronary disease and CTO PCI were significantly more likely to be associated with RASER (p <0.05).

Clinical outcomes of PCI by ELCA use

The unadjusted incidence of procedural complications and outcomes associated with RASER use are shown in Table 2. RASER use was associated with an increase in the crude numbers of arterial complications (5.3% v 1.5%, $p < 0.05$, unadjusted), and shock induction (2.6% v 0.2%, $p < 0.05$, unadjusted). There was a significantly higher total number of acute coronary complications with RASER cases compared to non-RASER ($p < 0.05$, unadjusted).

Multivariate logistic modelling of outcomes was used to adjust outcomes for baseline comorbidities and procedural variables (Figure 3). This showed that RASER use during PCI was significantly ($p<0.05$) associated with shock induction (OR 9.66, 95% CI: 3.44 – 27.06), slow flow (OR 3.50, 95% CI: 1.29 – 9.55) and arterial complications (OR 3.23, 95% CI: 1.58 – 6.61). RASER use was not associated with higher in-hospital MACCE, major bleeding or death.

DISCUSSION

The study findings can be summarised as follows: 1. RASER PCI was used in 0.02% of all PCI between 2006 and 2016; 2. RASER PCI was used in highly complex patients and procedures; 3. Following adjustment for baseline and procedural variables, RASER use was significantly associated with higher odds of slow flow, shock induction, and arterial complications; 4. In-hospital MACCE, death or major bleeding following RASER PCI was comparable to the non-RASER PCI cohort.

Adjusted modelling of baseline and procedural variables highlights the association of RASER use with higher BMI, older patients, number of lesions attempted, diabetes, hypertension, previous CABG, stable coronary disease and CTO PCI (Figure 2). These are consistent with the indications of RASER as described in the current (limited) evidence base in tackling complex calcific lesions including CTO[1]. However, we noted lower odds of RASER use with Graft PCI. The latter finding is not surprising since the use of rotational atherectomy is rarely undertaken in vein grafts given the concerns regarding coronary perforation[11,12].

The rate of RASER use showed an initial increase in 2006-2013 followed by a plateau. This echoes the pattern seen with ELCA use from the same dataset[3] and likely represents the natural history of operators gaining more expertise and confidence in using ELCA and RASER in the earlier years. The subsequent drop in RASER use after 2014 may relate to the development of lower profile balloons and stents, extension catheters and improved techniques to improve lesion crossing[13-15]. In addition, we noted a significant association of RASER use with the use of microcatheters and cutting balloons. The higher use of microcatheters is to be expected with this technique which frequently requires the delivery of the 0.009-inch RotaWire™ via a micro-catheter[1]. The higher use of cutting balloons may be explained by previous findings from the same database showing an overall increase in the use of cutting balloons in UK PCI practice over the same study period[16]. Alternatively this may reflect the complexity and the resistant calcific disease burden . This latter observation may have also contributed the drop in the rate of RASER use in more recent years (2015-2016) in favour of cutting balloons. The emergence of intravascular lithotripsy may further affect the use of RASER in calcium modification of non-dilatable lesions, although RASER is likely to continue to be used in non-crossable lesions [17,18]. The aging demographic of patients undergoing PCI which has been observed in many countries will also likely mean that calcium modification technologies as a whole will be increasingly important in future years [19-21].

The lack of a major effect of RASER on clinical outcomes (in-hospital MACCE) despite the increased rates of acute periprocedural shock, slow flow and arterial complications may reflect increased operator experience at managing complications and significant improvement in technologies to treat PCI-related complications. Nevertheless the safety outcome observations are reassuring and reflect an acceptable level of procedural risk in this complex patient group and no increase in in-hospital death or MACCE (Figure 3) and is testament to the skills of the small number of operators skilled enough to successfully undertake a RASER procedure. Finally, it is very likely that the uptake of this technique will remain a 'niche' indication, influenced by case selection, tool availability and operator experience.

The major strength of this study is that the BCIS National PCI data set includes >98% of all PCI procedures performed in the United Kingdom, which, therefore, reflects a national, real-world experience that includes high-risk patients encountered in daily interventional practice (who are often excluded from randomized controlled trials). Additionally, such large national registry data with unselected enrolment provides an almost unique opportunity to evaluate the safety of infrequently utilised techniques such as RASER.

There are several limitations to this study. Firstly, the BCIS database does not differentiate between complications arising directly from the use of RASER and complications arising from other steps in the PCI procedure. Secondly, the size of the ELCA catheter or RA burr used is not recorded and therefore insights into complication rates by catheter/burr size cannot be provided. Thirdly, radiation dose and use of contrast is not recorded as part of the database, and therefore the effect of RASER use on total case radiation/contrast volume cannot be investigated. Furthermore, current downloads of BCIS data from NICOR do not include longer term outcomes, which limits the interpretation of the study beyond procedural complications. Finally, as with any observational data, whilst the statistical adjustment aims to correct for baseline differences and complexity, confounders may remain which could influence the study findings. Consequently, conclusions need to be interpreted in the context of the observational nature of these findings.

CONCLUSIONS

The combined use of rotational and excimer laser coronary atherectomy ('RASER') in PCI is associated with higher risk baseline and procedural characteristics. Despite higher odds of shock induction and arterial complications, RASER does not increase the likelihood of in-hospital MACCE, major bleeding or death.

CONFLICTS OF INTEREST

ME is a proctor for ELCA and RA and has received honoraria and speaker's fee from Boston & Phillips.

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FIGURE LEGENDS

Table 1. Baseline participant characteristics by RASER use in patients undergoing PCI in England and Wales 2006−2016. SD: Standard deviation, BMI: body mass index, PCI: percutaneous coronary intervention, MI: myocardial infarction, CABG: coronary artery bypass grafting, LMS: left main stem, PVD: peripheral vascular disease.

Table 2. Procedural variables by RASER use in patients undergoing PCI in England and Wales 2006−2016. SD: standard deviation. CTO: chronic total occlusion, PCI: percutaneous coronary intervention, LMS: left main stem, LAD: left anterior descending, Cx: circumflex, RCA: right coronary artery.

Figure 1. Trends in RASER use in PCI performed in England and Wales 2006-2016. (A) Crude numbers of RASER (dark grey bars) and non-RASER PCI (light grey bars); (B) Percentage of RASER-PCI as a proportion of all PCI demonstrates an initial rise, subsequent plateau and recent decline(p for trend <0.001).

Figure 2. Multivariate logistic regression model of co-variates associated with RASER use in patients undergoing PCI in England and Wales 2006−2016. CI: confidence interval, PCI: percutaneous coronary intervention, CABG: coronary artery bypass grafting, CTO: chronic total occlusion

Figure 3. Adjusted outcomes of RASER use in patients undergoing PCI in England and Wales 2006−2016. CI: confidence interval, MACCE: Major adverse cardiac/cerebrovascular events, CABG: coronary artery bypass grafting, MI: myocardial infarction, PCI: percutaneous coronary intervention.

Supplementary Figure S1: Consort flow diagram for study population. PCI: Percutaneous coronary intervention, ELCA: excimer laser atherectomy, RA: rotational atherectomy, RASER: ELCA with RA.

Supplementary Table S1. Percentage of missing data in baseline, procedural and outcome variables

Supplementary Table S2. Crude outcomes by RASER use in patients undergoing PCI in England and Wales 2006–2016. MACCE: Major adverse cardiac/cerebrovascular events, MI: myocardial infarction, SD: standard deviation, CABG: coronary artery bypass grafting, PCI: percutaneous coronary intervention.