**Protocol number: CCU007\_11**

**Title: Trend, early and midterm clinical outcomes of cardiac surgical interventions during covid era**

Short title: Impact of COVID-19 on adult Cardiac Surgery volume, peri-operative and long term outcomes.

**Background**

Despite rigorous global and UK containment and quarantine efforts, the incidence of infection with SARS-CoV-2 and its morbidity and mortality (i.e. COVID-19) has remained a serious public health problem since it first emerged in early 2020. In the UK the ‘second wave’ starting in early September 2020 resulted in a greater burden on the NHS, and more deaths. Several articles have addressed the reorganisation of surgical activity under COVID-19. However, only a few, if any, have focused on the impact and the management of adult cardiac surgery.

Approximately 30000 adult cardiac surgical procedures were performed annually in the UK before the pandemic. The volume has reduced significantly during the pandemic as reported by the National Institute for Cardiovascular Outcomes Research (NICOR). For instance, the number of cardiac surgeries performed in 2019/2020 has reduced to 19359 and has slowly recovered annually since. However, limited by the complexity and large volume of the database, patient-specific characteristics were not evaluated and reported.

Recently there has been a shift from sole focus on in-hospital mortality to morbidity/quality of life indicators in all surgical specialities, including cardiac surgery. The top priority (out of 10 priorities) for adult heart surgery research (Part of the National Cardiac Surgery Clinical Trials Initiative) includes quality of life (e.g. disability-free survival) following cardiac surgery. Hence, attentions are drawn into the incidence of stroke, atrial fibrillation, re-hospitalisation, and repeat intervention. Moreover, gender, equality and diversity are also an important research focus when evaluating surgical outcomes. Whether COVID-19 have played a role in the above status still needs to be fully evaluated.

Surgical volume and association has been widely reported in many surgical specialities. With a reduction in volume in both individual surgeon and units, the level of competency may have changed after the pandemic and this needs to be investigated. Patient risk profile, medical management and non-operative approaches should also be considered to evaluate unexplained variation in clinical practice.

**Objectives**

**Primary objectives:**

1. Compare trend, surgical priority, in hospital and mid-term outcomes in patients who underwent cardiac surgery (CABG, AVR, MVR, major aortic, other) before or during the COVID-19 pandemic.

**Secondary objectives**

Evaluate in patients who underwent cardiac surgery before or during the COVID-19 pandemic:

1. quality of life indicators (Re-admission, repeat intervention, Event-free survival)
2. ii) gender, equality and diversity status

iii) impact of COVID-19 on surgical volume at individual surgeon and Unit levels and its relationship or variation in case selection/mix .

**Statistical Analysis**

Population:

All adults who underwent cardiac surgical procedures from 2013 to 2023 (or the latest data available). Patients who underwent congenital cardiac surgery, transplant and mechanical support device insertion were excluded.

Exposure:

Periods of national lockdowns and relaxation

Pre lockdown :01 Jan 2018 to 22 Mar 2020

First lockdown :23 Mar 2020 to 23 Jun 2020

First relaxation: 24 June 2020 to 05 Nov 2020

Second lockdown :05 Nov 2020 to 02 Dec 2020

Second relaxation :03 Dec 2020 to 05 January 2021

Third lockdown :06 Jan 2021 to 07 Mar 2021

Third lockdown relaxation :08 Mar 2021 to 21 Jun 2021

**Clinical Outcomes:**

Primary outcome

1. In-hospital/30-day and follow up mortality

Secondary outcomes

2. Length of hospital stay

3. Neurological complications (Postoperative Delirium, Stroke and Transient ischaemic attack)

4. Postoperative need for renal dialysis

5. Return to theatre for bleeding

6. Respiratory complications (prolonged ventilation- more than 48 hours)

7. Quality of life indicators (Re-admission, repeat intervention, Event-free survival)

8. Equality and diversity (Sex, Race, Socioeconomic status)

9. Volume and association, Variation in practise

**Data linkage**

Analyses will be based on:

• England - National Audit of Cardiac Rhythm Management (NACRM), Myocardial Ischaemia National Audit Project (MINAP), National adult Cardiac surgery audit (NACSA), Prescribing/Dispensing, General Practice Extraction Service (GPES) Data for Pandemic Planning and Research (GDPPR), Hospital Episode Statistics (HES), Covid-19 Lab Tests, ONS Death registry.

• Wales - Welsh Longitudinal General Practice (WLGP), Critical Care Dataset (CCDS), (EDDS), Outpatient Dataset for Wales (OPDW), Patient Episode Dataset for Wales (PEDW), COVID-19 Test Results (PATD), Covid Vaccination Dataset (CVVD), Annual District Death Daily/Monthly, COVID-19 Consolidated Deaths (CDDS), ICNARC – Intensive Care National Audit & Research Centre (ICCD), Wales Dispensing Dataset (WDDS), NICOR Audits and Registers (NICO), HQIP Stroke Audit (HQIP), National Vascular Registry (NVR), National Community Child Health (NCCH) and Office of National Statistics Census (CENW, 2011).

• Scotland - Scottish morbidity record (SMR00, SMR01), Electronic Communication of Surveillance in Scotland (ECOSS), Scottish Intensive Care Society Audit Group (SICSAG) and Scottish Stroke Care Audit (SSCA).

**Outcome definitions:**

Procedure based episodes:

Episode starts form the date of the first surgical operation to the 30th day. All the subsequent procedures within this 30-day period will be considered as part of the first episode. We will assign the post procedure complication and vital status of the patient at the end of the 30-day period. Any subsequent surgical operation after the 30 days from the start of the first episode will be considered as a new episode.

Type of Surgery:

As per NACSA and HES OPCS 4.9 Code.

Surgical priority:

Categorises the patient in terms of the urgency.

• Elective: Routine admission from the waiting list.

• Urgent: Patient’s condition requires urgent intervention (They cannot be sent home without a relevant procedure).

• Emergency: Unscheduled patients with ongoing cardiovascular compromise or hypoxia. Requirement for procedure within 24 hours irrespective of the time of day.

• Salvage: Patients in imminent risk of demise without intervention

COVID vaccination status:

Date and time, Vaccination Procedure code.

COVID test results:

Test results, Record created date.

Mortality related to procedure:

In-hospital (NACSA), or long term > 12 months (ONS)

Length of Stay in Hospital (HES and NACSA):

Time in days from admission to discharge within one episode.

Euroscore II: Overall surgical risk of patient

Post operative complications

(stationary variables in NACSA and longitudinal variables in HES, ICNARC, and NACRM)

Postoperative stroke

Postoperative need for renal dialysis/renal support

Postoperative atrial fibrillation

Rates of return to theatre for bleeding

Respiratory complications (prolonged ventilation- more than 48 hours, method of respiratory support – mechanical ventilation)

Destination on Discharge

Destination on Discharge (HES APC)

**Covariates**

Sex: data from NACSA (categorical)

Weight: data from NACSA (continuous)

Height: data from NACSA (continuous)

Urgency: data from NACSA (categorical)

Date of Surgery: data from NACSA (date)

Date of Angiogram: data from NICOR minap (date)

Age in days, at date of visit; GP; (Date of visit from NACSA/HES and Date of birth from GDPPR)

Severity of illness: CCS and NYHA classifications from NACSA (categorical)

Preoperative comorbidity: Diabetes, Hypertension, Peripheral Vascular Disease, Chronic Obstructive Pulmonary Disease, Renal Dysfunction, Neurological Dysfunction, Recent MI, date last MI, NYHA Class, CCS Class, LV function, Endocarditis, Preop Critical Illness from NACSA (categorical).

Ethnicity: (Asian or Asian British, Black or Black British, Mixed, Other ethnic group, and White) data from Hospital Episode statistics (categorical)

Deprivation: Most recent decile of deprivation prior to start of study, defined using median of Index of Multiple Deprivation (IMD) for each Local Authority District

Date of Admission: data from HES (Date)

Diagnostic Code associated with Admission: data from HES (Categorical)

Admission and discharge dates (LOS) in ITU: data in days from ICNARC (continuous)

Number of days requiring advanced respiratory care (mechanical ventilation): data in days from ICNARC (continuous)

Number of days requiring advanced cardiovascular care (inotropic support): data in days from ICNARC (continuous)

Number of days requiring renal care: data in days from ICNARC (continuous)

**Stratification variable definitions:**

We will explore whether differences in case-mix, including urgency, complications and mortality differ in the following groups.

The group definitions below reflect the ideal but once we have explored the data these may be collapsed if the numbers are too small within some categories for meaningful analyses.

Age-groups: 18-30, 31-40, 41-50, 51-60, 61-70, 71-80 and 81-90.

Sex: male, female

Ethnicity: data from HES: (Asian or Asian British, Black or Black British, Mixed, Other ethnic group, and White)

Deprivation: Most recent decile (10th) of deprivation prior to start of the study, defined using Index of multiple deprivation (IMD) scores

Region: Defined as the highest level of sub-national division of England for administrative purposes: East England, London, Midlands, North West, North East and Yorkshire, South East, and South West (data from GDPPR dataset).

**Analysis:**

The number of procedures and perioperative outcome will largely derived from the NACSA and HES database. The type of specific procedure grouping (case mix), surgical priority, proportion of death, and any post operative complications during the different time periods will be compared. We will use Chi-square test to compare the proportion between different time periods and means and standard deviation for the continuous variables will be compared to using appropriate parametric (t-test) or non-parametric (Mann-Whitney’s U) tests. Multivariable logistic regression analysis will be used to estimate the risk of death and post operative complications related to procedures between pre-pandemic and pandemic time periods after adjusting for the covariates.

Additional analyses will explore whether associations differ by age, sex, geographical region, area deprivation and ethnicity, using categories defined as above but collapsing these if necessary, because of small numbers.

Data sources

NHS Digital TRE for England (up to latest release)

ONS - Office of National Statistics (ONS) death registration records

NACSA - (National Institute for Cardiovascular Outcomes Research (NICOR))

GDPPR - General Practice Extraction Service (GPES) Data for pandemic planning and research

HES - Hospital Episode Statistics

ICNARC - Intensive Care National Audit and Research Centre

NACRM - National Audit of Cardiac Rhythm

**Data Management**

The NACSA (NICOR) dataset will provide the information related to the procedures like the diagnosis codes, procedure codes, date of the surgery, gender, complications and associated comorbidities. GDPPR dataset will used to link the data for the patient characteristics like date of birth, ethnicity, region, deprivation index etc. The ONS death registration records will be linked to access information on death which were missed in the NACSA dataset. HES dataset will be used to analyse longitudinal changes in complications. ICNARC will be used to examine respiratory outcomes. NACRM will be used to analyse postoperative cardiac rhythm related complications.

**Patient or user group involvement**

This study does not directly involve patients, however knowledge of impact of COVID-19 on the adult heart surgeries is of interest to the public.

**Plans for disseminating and communication study results.**

We will publish the results of the study immediately on completion of analyses and paper drafting on a preprint server such as medRxiv (https://www.medrxiv.org/). At the same time as placing on the pre-print server we will submit for open-access peer-reviewed publications. We will disseminate findings to the wider COVID-CVD group, the BHF-NIHR network (including meetings with patients) and through national and international conferences as are appropriate. Depending on the findings, we will also explore additional options for focussed dissemination within appropriate communities. We will make our code available through the BHF Data Science Centre GitHub and finalize the protocol prior to commencing analyses.