NHS England
Cheshire & Merseyside
Strategic Clinical Networks

Pathway to improve access to emergency angiography for comatose patients following cardiac arrest due to myocardial infarction in Cheshire and Merseyside

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Background

Patients who suffer a cardiac arrest outside hospital (OOHCA) have an extremely high mortality rate. Within the group who are successfully resuscitated to achieve a return of spontaneous circulation (ROSC), those who are comatose immediately afterwards, accounting for up to 80%, have historically had a very high mortality and neurological morbidity rate. It is recognised from autopsy and immediate coronary angiography data that significant coronary artery disease may be documented in over 70% of patients with OOHCA but their optimal treatment remains unclear.[1]

There are no RCT investigating the benefits of an immediate invasive coronary strategy in OOHCA resuscitated patients. A recent meta-analysis of 10 observational studies (n=3,103) suggested an immediate invasive strategy was associated with improved survival (pooled unadjusted OR 2.78; 95% CI: 1.89-4.10; p<0.001)[2]. However the heterogeneity of studies and lack of data for adjusted analysis makes interpretation of this data difficult[3]. An expert consensus document regarding the optimal invasive management of survivors of OOHCA has been published by the EAPCI which is designed to guide interventional cardiologists in the face of limited published data.

The following general recommendations are made:

A. selection of patients for immediate coronary invasive strategy

1. Up to 80% of resuscitated patients present in coma despite ROSC, which indicates post-resuscitation brain injury, the severity of which may vary from no or mild disability to permanent vegetative state or brain death. *Importantly, this cannot be accurately predicted on hospital admission*.

2. Comatose survivors of OOHCA with ECG criteria for STEMI on the post-resuscitation ECG should follow the "STEMI fast track" and go directly to the catheterisation laboratory.

3. For patient without STEMI ECG criteria, whilst coronary disease is likely, there are many other possible causes of cardiac arrest. A short "emergency department or intensive care unit stop" to exclude non-coronary causes, such as respiratory failure, shock of non-cardiogenic aetiologies, cerebrovascular event, pulmonary embolism and intoxication, by performing the appropriate diagnostic procedures is advised. A routine head CT is NOT recommended unless CVA is thought to be primary diagnosis.

4. Unfavourable criteria which predict a remote likelihood of neurological recovery should be considered before a decision for an invasive coronary strategy is made. These include:

- Unwitnessed cardiac arrest
- >10 mins before basic life support is commenced
- Presence of a non-shockable rhythm
- >20 mins before ROSC
- Severe pre-arrest comorbitities
- Limited life expectancy

These criteria are individually of low predictive value and detailed consideration of these should not delay transfer of the patient. Where factors are unknown, they should be assumed to be favourable

5. Prehospital triage and regional networks for the management of OOHCA patients should be promoted. Direct transfer to the regional centre should be considered for all survivors with appropriate STEMI ECG criteria.

6. If an OOHCA patient with appropriate STEMI criteria is admitted to a non-interventional hospital, **transfer should be achieved within 2 hrs** *and thrombolysis should be considered if this time frame cannot be achieved.*

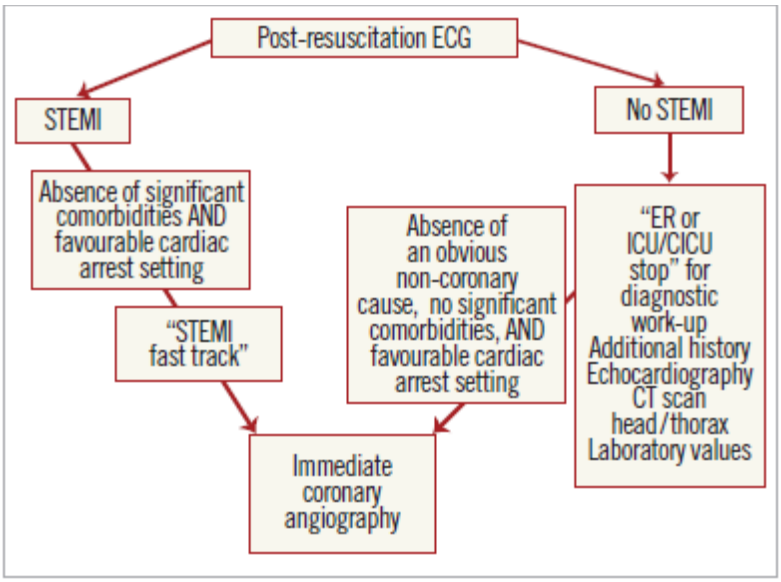

Figure 1. *Selection of patients for immediate coronary invasive strategy. CICU: specialised cardiac intensive care unit; CT scan: computed tomography scanner; ECG: electrocardiogram; ER: emergency room; ICU: intensive care unit; STEMI; ST-segment elevation myocardial infarction. See text for the definition of favourable cardiac arrest setting.*

B. Cardiac arrest PCI (CA-PCI)

Coronary angiography after resuscitated OOHCA may reveal very heterogeneous findings particularly in patients without ST-elevation. The aim of CA-PCI is to reduce the incidence of recurrent cardiac arrest, to reduce infarct size in case of an acute occlusion and thereby to improve the haemodynamic status. In comatose survivors, who represent a major subgroup of resuscitated OHCA patients, stabilised haemodynamic status may allow enough time for possible neurological recovery during the following days.

The following general recommendations are made:

1. Immediate CA-PCI should be performed in clear "ACS" lesions

2. In the absence of data, non-culprit PCI should probably be postponed despite very recent evidence indicating possible benefit in STEMI without OOHCA.

3. Index CA-PCI of additional non-culprit but obviously obstructive lesions with stable angiographic appearance may be beneficial if the patient is haemodynamically unstable.

4. Immediate coronary artery bypass grafting**,** (CABG) is a realistic option only in conscious survivors of OOHCA on hospital admission with severe multivessel disease and not in comatose patients in whom the ultimate neurological outcome is difficult to predict

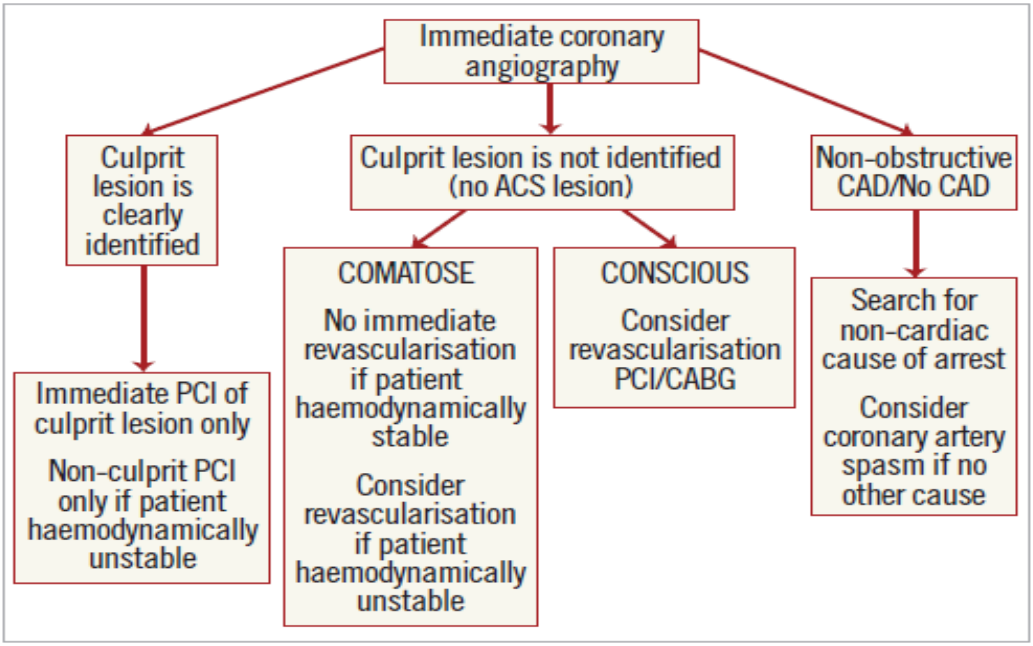

Figure 2. *Revascularisation strategies in survivors of out-of-hospital cardiac arrest. ACS: acute coronary syndrome; CABG: coronary artery bypass graft surgery; CAD: coronary artery disease; PCI: percutaneous coronary intervention*

C. Induced hypothermia

Previous local guidelines describing the pathway for OOHCA patients being transferred for PCI at LHCH placed emphasis on pre-procedure cooling protocols. This advice was based on the publication of two randomised trials in 2002 which demonstrated the benefit of mild induced hypothermia between 32 and 34°C in comatose survivors of OOHCA[4,5], and the subsequent International Liaison Committee on Resuscitation (ILCOR) 2010 guidance[6]. However, recent trials cast some doubt on the validity of aggressive early cooling, demonstrating that maintaining target core temperature at 36°C may be sufficient to facilitate neurological recovery[7]. ILCOR guidance for comatose survivors of OOHCA with a shockable rhythm has yet to reflect this new data but an update on their website suggests that "some clinicians may make a local decision to use a target temperature of 36°C pending this further guidance"[8]. Suffice to say, there is no current evidence to support delaying invasive angiography whilst aggressive hypothermia is induced.

Current Regional and Local Status

Currently patients suffering a cardiac arrest caused by a STEMI are being cooled on intensive care units across the region, which is the best therapy to protect their brain and improve their survival. They are also receiving medical therapy for MI but their access to PCI appears to be limited. A service evaluation from Lancashire Cardiac Centre suggests that between 2008 & 2011 of 19 OOHCA patients meeting ECG criteria, only 5 underwent primary PCI. During this time, only one OOHCA patient was transferred in from another hospital for PCI[9]. There is currently no data describing practice at the other cardiac centres in the region.

NWAS has provided data regarding all OOHCA where resuscitation was commenced and continued through conveyance to hospital, for the period 2013-2014, Table 1. The presenting rhythm was VF or VT in 23%. Bystander CPR was commenced in 55%. The data below suggests that in the Cheshire and Merseyside region, a total of 128 patients suffered an OOHCA where the presenting rhythm was VF or VT, and survived with

ROSC on arrival to hospital. Of these, we can estimate that up to 80% may be in a comatosed state. No data is available on how many reach STEMI criteria on ROSC.

Hospital	Total OOHCA	All VF/VT OOHCA	VF/VT OOHCA with ROSC
Arrowe Park	124	34	10
COCH	103	24	11
Aintree	112	33	14
LHCH	19	16	16
RLUH	128	40	23
Southport	80	28	14
Warrington	113	32	18
Whiston	151	47	22
(totals)	830	254	128

Table 1. NWAS OOHCA audit data for Cheshire and Merseyside, 2013-2014[10].

Data from LHCH for the same period 2013-2014 demonstrates 23 mechanically ventilated patients accepted for PCI, 22 as primary PCI (PPCI, indicating STEMI criteria ECG), and 1 as unstable ACS PCI (NSTEMI ECG criteria). However, these numbers have risen over the past 3 years, as demonstrated in Table 2, which details LHCH audit figures for the period 2011-2014[11]. Extrapolating the Lancashire Cardiac Centre data to the Cheshire and Merseyside population, we might predict 20-25 cases per year and this is in keeping with recent figures for 2013-2014. The NWAS data however might indicate that this population represents only a proportion of eligible patients and with an established service, there may be additional demand.

Intra-aortic balloon pumps (IABP), a mechanical device used to support blood pressure and mitigate ischaemia in patients in cardiogenic shock are used in a large minority of ventilated patients treated by PCI. This has implications for the regional service as patients with IABP placed will need to remain in LHCH rather than be repatriated to their local ITU.

Year	No. Ventilated patients transferred emergently to cath lab	Patients for PPCI (STEMI criteria)	Patients for emergency ACS PCI (NSTEMI criteria)	Use of IABP
2011	12	11	1	7
2012	14	11	3	8
2013	23	22	1	10
2014, year to date	25	24	1	6

Table 2. LHCH audit data. Number of ventilated patients treated emergently in cath lab.

Review of Current Guidance

It is recognised that critical care patients in non-cardiac centres, who could benefit from PCI have more limited access to an emergent coronary invasive strategy. On 5th October 2012 there was a joint critical care networks conference with consultants representing critical care and cardiology in attendance. It was agreed that it would be desirable to develop a pathway for appropriate patients to be transferred to cardiac centres to receive PCI. Version 3.1 of this pathway was published in September 2013. This new guidance aims to incorporate the consensus statement from the European Association for Percutaneous Cardiovascular Interventions (EAPCI)/Stent for Life (SFL) groups, and new evidence regarding induced hypothermia[3,8].

In the main, the pathway remains unchanged. However, as for conscious STEMI patients the goal is for coronary intervention to be achieved as quickly as possible: “Time is Muscle”. Therefore, in appropriately selected comatose OOHCA patients, emphasis is placed on the following:

- Transfer from local A&E to LHCH should occur within 2hrs. Anticipated delay should prompt consideration of thrombolysis in patients with STEMI criteria.

- Prolonged discussion in appropriate patients with clear evidence of STEMI on their ROSC ECG should be avoided. The PPCI pathway should be activated as for conscious STEMI patients. However, this necessitates assessment and decision making by a senior clinician at the referring hospital, and should not be done in the absence of senior review.

- Aggressive pre-transfer induced hypothermia is not required. Timely transfer for PCI should not be delayed by cooling protocols.

- Transfer requires appropriate senior A&E/ITU consultant review but this does not include diagnostic investigations (brain/thorax/whole body CT) unless specifically indicated (non-coronary cause of OOHCA suspected).

- Transfer requires appropriate anaesthetic/ITU support. However, invasive monitoring is not required prior to transfer. Arterial access will be gained during the procedure, and additional CVP lines etc. can be inserted post procedure. Urinary catheters, NG tubes etc. can be placed post procedure and again should not delay transfer.

- It is anticipated that increased demand on the service will require more patients to be repatriated to their local ITU post procedure. This will be co-ordinated by ITU at LHCH.

Proposed pathway for Comatose Survivors of Cardiac arrest due to MI

1. Patients suffering an OOHCA are transferred by emergency ambulance to the nearest A&E department (no change to current practice).

2. The patient should be reviewed by senior A&E clinicians and, in discussion with the consultant responsible for critical care, a decision regarding suitability for ICU admission is made, before a decision to transfer the patient to LHCH is undertaken (no change to current practice).

3. If ROSC 12-lead ECG suggests STEMI, and the patient is deemed suitable for both critical care admission and an invasive coronary strategy after assessment by a senior clinician, the PPCI pathway should be activated. There is an expectation that once activated, a senior clinician will contact the on call cardiology SpR at LHCH to alert them to the incoming ventilated patient. This is crucial to allow coordination of ITU/anaesthetic teams at LHCH to receive the patient.

4. Patients will be transferred by NWAS as a matter of urgency and will have an airway-trained medical escort. NWAS crews bringing a comatose survivor of out-of-hospital cardiac arrest to an A&E department should stand by for immediate onward transfer of patients to LHCH, once this has been agreed.

5. Patients without ST-elevation, but with good ECG evidence of significant on-going ischaemia, such as widespread profound ST-segment depression, should also be considered for transfer. If there is doubt about the indication for primary PCI, and in all cases without ST-segment elevation, the ECG's should be faxed to LHCH for discussion to avoid the situation where a patient is deemed inappropriate for PCI after arrival at LHCH. As the transfer to a PCI centre involves a tangible risk and access to an expensive resource, a suitably-experienced SpR or a consultant should be involved in the decision to refer/transfer.

There is an expectation that a senior member of the A&E, critical care or cardiology teams at the referring hospital will discuss with the cardiology registrar on-call at LHCH ('PCI hotline' number 07769 135 883, or rapid response switchboard call 0151 600 1817, and subsequently fast bleep the cardiology SpR for immediate response).

6. The cardiology registrar at LHCH will activate the PPCI pathway at LHCH, informing switchboard that a ventilated patient is expected and that an ODP and anaesthetist will be required.

8. The cardiology registrar will contact critical care on-call at LHCH to confirm availability of a critical care bed for the patient post-procedure. If there is no critical care bed available at LHCH, then the referring hospital will be informed that the patient will be repatriated to them immediately after PCI. It will then be the referring hospital's responsibility to arrange for a suitable critical care bed. Advice on post-procedure management including medication and access-site care will be provided. Patients will be cared for at LHCH in all cases where mechanical support of the circulation (e.g. by intra-aortic balloon pump) is indicated. Discussions on bed availability should not delay transfer and should take place after the PPCI pathway has been activated.

11. If the patient is not for transfer, then care will be at the referring unit as previously. If the decision is made that the cardiac arrest was due to cardiac disease but the patient is not for transfer, ongoing cardiology input and eventual follow up will be from the referring hospital.

12. Transfer should not be delayed by referring units inserting invasive monitoring. Please ensure the right radial artery is not used for arterial blood gas sampling or line insertion and keep this area free of venous cannulae as this is the most-commonly used route of access for the angioplasty procedure.

13. Portable cooling pads (e.g. Emcool) or other devices can be used to cool the patients before and during transfer (and throughout angiography). These should be available in the A&E department of referring hospitals. However, aggressive cooling should not delay transfer to LHCH if the decision for immediate invasive angiography has been made.

11. Transfer to catheter lab will be treated as a matter of urgency by the critical care team, as the benefits of revascularisation are time dependent. A delay of less than 2hrs between arrival and assessment in A&E and transfer to LHCH should be achieved. If assessment and transfer is likely to be delayed beyond 2 hrs then thrombolysis should be considered.

12. Care of the patient will be handed over to the cardiologist and the anaesthetist covering the catheter lab at LHCH.

13. Anaesthetic support for the patient whilst the patient is in LHCH will be provided by the LHCH team.

14. If the patient is being repatriated to the host hospital, the transferring team may be asked to wait until the procedure is complete; however, the team needs to confirm that there is a bed available in the host hospital and the consultant for the critical care unit at the host hospital is aware of the transfer. If during the PCI procedure it becomes clear that the PCI procedure will take longer than usual (20-30 minutes), the transferring team should be released, and any necessary transport rearranged after the procedure.

15. If there is no critical care bed at the referring hospital, the critical care consultants at LHCH and the referring hospital should discuss the options; the ultimate responsibility for finding a suitable bed lies with the critical care consultant from the referring hospital.

16. if the patient is admitted to LHCH critical care, repatriation should be prioritised by the host hospital as soon as LHCH critical care deems the patient suitable for repatriation.

16. After angiography and, where appropriate, PCI, the patient will be transferred to critical care under the care of a cardiology consultant, either in LHCH, or their local ITU if being repatriated.

14. The cardiology team at LHCH will be responsible for referring the patient to a cardiologist in the referring trust, to whose care the patient will be transferred.

15. If the patient survives to ITU discharge, they will go to a ward under the care of the local cardiologist who will assess their need for ICD implantation, surgery, electrophysiological studies, etc. prior to their discharge.

Key messages:

1. Ventilated survivors of out-of-hospital cardiac arrest who have ST-elevation on their ECG should be transferred immediately to LHCH for primary intervention. After acivating the PPCI transfer, LHCH must be informed by the referring unit that a ventilated patient is *en route.*

2. Ventilated survivors of OOHCA without ST-elevation should be discussed immediately with the cardiology SpR at LHCH. The expectation is that, where an ischaemic cause is suspected and there is no clear non-cardiac cause for their cardiac arrest, the patient will be transferred for immediate invasive investigation.

3. The patient should be assumed to have the potential for a good neurological outcome unless there is strong evidence to suggest otherwise, and detailed consideration of prognosis should not delay transfer.

4. Discussions on which intensive care unit will take the patient after the procedure should not delay transfer and will usually only take place after activation of the PPCI pathway.

Cost considerations

Current data indicates 20-25 cases per year. It is possible that this will increase, particularly in light of NWAS data. Not all comatose patients with OOHA and ROSC will be deemed suitable for transfer however and a significant increase in numbers (>20%) is unlikely.

Costs:

Transfers

This will add less than 10 emergency transfers per annum to the workload of NWAS.

Interventional cardiology

Although there is no new cardiology service being offered, this pathway will encourage access for those who are already eligible to receive it.

Critical Care

Under the PbR framework, the critical care costs will simply be shifted between referring and receiving units, with no net additional cost to the commissioners. It is anticipated, particularly if numbers rise, that patients will be increasingly repatriated to their local critical care – the referring unit - impacting on their PbR income

Appendix 1: **Management of patients transferred back to referring hospital after primary PCI for acute myocardial infarction**

This documents the advice for the immediate post-procedure management of patients who have undergone emergency PCI for acute myocardial infarction and are transferred to the intensive care unit of another trust for continuing treatment, such as when the patient remains comatose or sedated after cardiac arrest.

1. **Management of the arterial puncture site**

a) Radial artery.

A 'TR-band' will have been applied to the patient's wrist at the end of the procedure. This is a bracelet with a Velcro fastening, with an air-filled cushion applying pressure over the radial artery puncture site. The balloon is inflated and deflated by inserting the dedicated syringe into the inflation valve to allow air to be injected or released (similar to the cuff on an endotracheal tube). The principle of its use is to apply the minimum amount of pressure to achieve haemostasis whilst allowing anterograde flow through the radial artery. In most patients 12-15ml of air will have been injected into the balloon; injecting more than 20ml will risk rupturing the balloon.

On arrival at the receiving unit: Ensuring the site is satisfactory and secure. If there is bleeding from the puncture site, inject 1-2ml air into the balloon until the bleeding stops. Note the volume of air in radial band. This should be recorded in the documentation sent with the patient

From one hour after application of the TR-band, withdraw 2-3ml air every 20-30 minutes until all the air is removed. If bleeding occurs at any point, re-inject 2-3ml air and observe.

Once all the air has been removed, leave the radial band in situ for a further 15-20 minutes then remove using an aseptic technique and apply a clean dressing.

The patients hand may be pink due to the chlorhexidine used as skin prep for the procedure.

Whilst the TR band is in-situ ensure the hand can be observed for any colour changes (do not cover it with a sheet). If the hand becomes purple / blue the band may be too tight, leading to venous congestion. The band should be loosened by carefully releasing and reattaching the

Velcro. A white, cold hand may result from too much pressure being exerted on the radial artery and a couple of ml of air may need to be removed to improve perfusion.

b) **Femoral artery (sheath removed).**

If the sheath has been removed, a closure device such as an Angioseal will have been deployed to aid haemostasis and a dressing will usually have been applied. The site should be checked every 30 minutes for the first two hours and hourly for the next four hours. If bleeding occurs, apply manual pressure and seek medical advice. Observe for haematoma formation around the site. If this occurs apply manual pressure. Check pedal pulses each time the site is checked to ensure adequate perfusion of the leg.

If the patient is conscious, advise them to apply firm pressure to the puncture site if they cough, laugh, sneeze or pass water, as all of these things can result in a bleed.

Ask the patient to inform staff if:

☐ The leg feels warm / wet and they think it may be bleeding

☐ The leg feels numb

☐ The patient feels dizzy / sick / sweaty

c) **Femoral artery (sheath in-situ)**

If the patient has received heparin or bivalirudin during the procedure, the activated clotting time should be checked two hours after the procedure, and, if it is less than 150 seconds, the sheath can be removed. If an ACT test is not available, an APPT ratio of less than 1.8 should be used. If low molecular weight heparin has been used, clotting tests are unhelpful. The sheath should be removed four hours after the procedure, or six hours if a GpIIb/IIIa-inhibitor infusion is running, e.g. abciximab (ReoPro), tirofiban (Aggrastat) or eptafibitide (Integrellin), or if abciximab was used during the procedure.

To remove the sheath, an aseptic technique should be used. The area around the sheath should be infiltrated with local anaesthetic if the patient is conscious. Vagally-mediated bradycardia and hypotension may occur, so intravenous fluids and atropine should be available. The suture retaining the sheath should be cut, then the sheath withdrawn whilst pressure is applied over the arterial puncture site (this is usually a centimetre or so above the skin incision). If you are

pressing in the correct place, you should usually be able to prevent bleeding with one or two fingers. Pressure should be applied for 10 minutes, or longer if further bleeding occurs. If a venous sheath is also present the arterial sheath should be removed first and haemostasis secured before removing the venous sheath in a similar fashion. Once haemostasis has been secured a dressing should be applied and the site observed as above.

2. **Post-procedure investigations**

The following are recommended, more frequent tests may be performed as required:

FBC: after 4 and 12 hours if GPIIbIIIa has been used. Daily until stable.

U&E: daily until stable

CKMB: 6 and 12 hours after presentation or Troponin 12 hours after presentation

CXR: as per local protocol for intubated patients.

ECG: on arrival on receiving unit, 12-24 hours after presentation and pre-discharge.

Echocardiogram: 24 to 48 hours post-procedure. Repeat at 6 weeks if initial echo shows poor LV function.

3**. Medication**

Dual anti-platelet therapy (aspirin plus one of ticagrelor, clopidogrel or prasugrel) is vital and should be given via the nasogastric tube from admission:

Aspirin 75mg o.d.

Ticagrelor 90mg b.d. /clopidogrel 75mg o.d. / prasugrel 10mg o.d.

Other antithrombotic/antiplatelet medication: heparin and LMWH are not usually continued after the procedure. If given, abxicimab should be continued to complete a 12-hour infusion and other GpIIb/IIIa infusions are usually given for 12-24 hours.

Betablockers – if the patient is not bradycardic or hypotensive, or requiring inotropic support:

Bisoprolol 2.5mg stat, then 2.5 mg o.d, increasing as tolerated to 10mg o.d.

ACE-inhibitor – if the patient is not hypotensive or in renal failure:

Ramipril 2.5mg at night starting the day after admission, increasing to 2.5mg b.d. the next day then 5mg b.d. as tolerated.

Statin

Atorvastatin 80mg o.n.

Other medication, such as eplerenone, may be required if LV function is poor, on the advice of the local cardiologist.

4. **Continuing cardiology care**

The cardiologist at LHCH will be happy to provide further information and advice as necessary.

Your local cardiologist should be involved in the care of the patient as soon as is practically possible and will provide additional advice. When ITU is no longer deemed necessary, the patient should be transferred to the coronary care unit or ward under their care.

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