

# ECMO (extracorporeal membrane oxygenation) services in NSW

Adult patients

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The information is not a substitute for healthcare providers' professional judgement.

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# ECMO model of care – at a glance

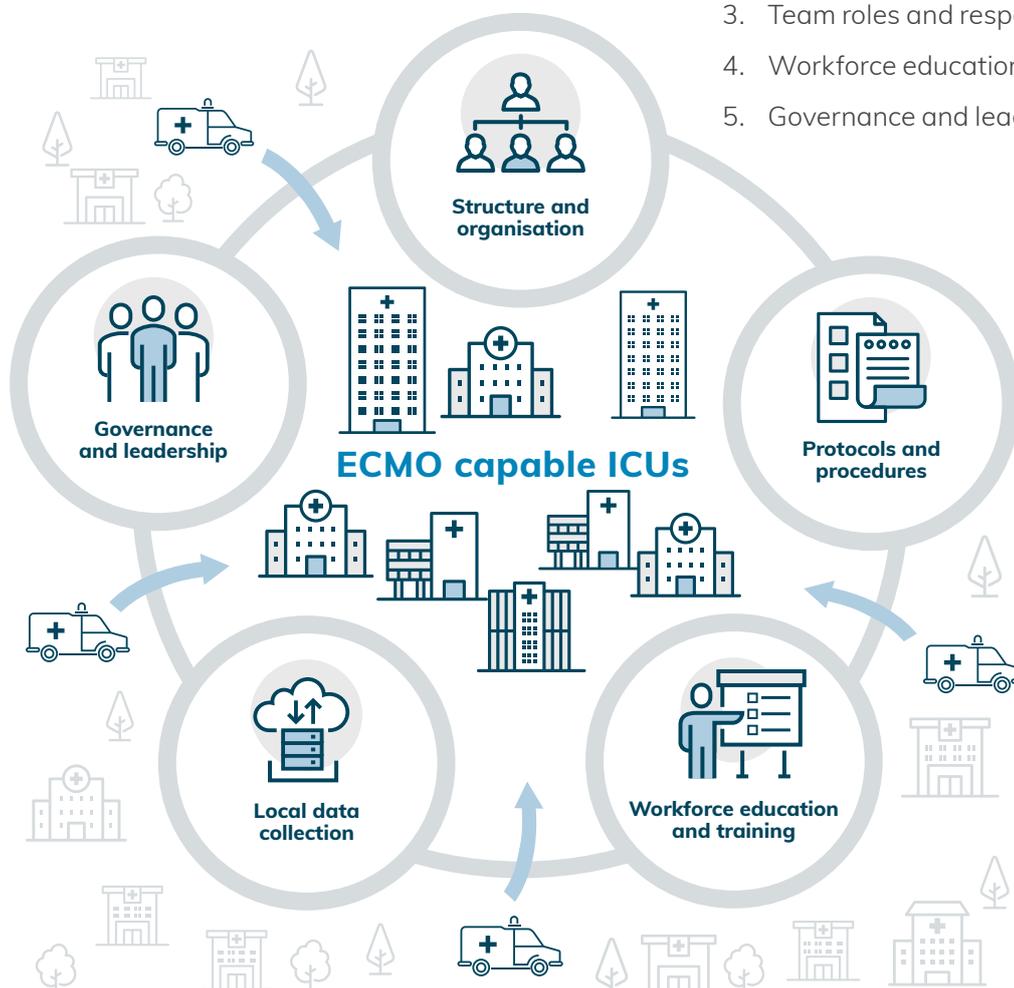
Extracorporeal membrane oxygenation (ECMO) is an advanced form of life support targeted at the heart and lungs. It may be indicated in cases of acute severe cardiac or pulmonary failure that is potentially reversible and unresponsive to conventional management. Eight intensive care units (ICUs) currently provide ECMO services in NSW. Two of those ICUs manage a retrieval service for the state.

The NSW adult ECMO model of care aims to ensure:

1. Patients receive appropriate care at the right time and place.
2. Clinicians are supported to deliver high quality care.
3. Information, collaboration and cooperation play a central role in ensuring services are safe, effective, resilient and sustainable.

The model has been informed by a rapid review of the peer reviewed and grey literature and consultation with the clinical community in NSW. It incorporates five core principles.

1. Structure and organisation
2. Protocols and procedures
3. Team roles and responsibilities
4. Workforce education and training
5. Governance and leadership.



# Summary

Extracorporeal membrane oxygenation (ECMO) is an advanced form of life support targeted at the heart and lungs. It may be indicated in cases of acute severe cardiac or pulmonary failure that is both potentially reversible and unresponsive to conventional management. ECMO can also be used as a bridge to heart and/or lung transplantation. There are two main types of ECMO, venovenous (V-V) and venoarterial (V-A). V-A ECMO provides haemodynamic support while also providing oxygenation and V-V ECMO provides respiratory support.

ECMO is a high-risk invasive intervention with a significant burden of complications, in particular the risk of bleeding and infection. The maintenance of patients on ECMO is also resource intensive.

Patients generally require a high level of nursing care and on-site medical supervision. Multidisciplinary teams that are appropriately trained have been shown to improve patient outcomes, limit adverse events and positively impact patient and employee satisfaction across a range of conditions and specifically for ECMO.<sup>1,2</sup>

There is some evidence of a volume–outcome relationship in ECMO. Patients who receive ECMO at hospitals with more than 20 annual cases have had significantly better outcomes (Safer Care Victoria, 2020). This supports the use of patient transport services to larger expert centres. Volume, however, is only one contributory factor to good outcomes.

In NSW, eight ICUs currently provide ECMO services. The state ECMO retrieval services is coordinated by NSW Ambulance and Royal Prince Alfred Hospital (RPAH) and St Vincent’s Hospital. Between 2016 and 2019, there were 100 retrievals considered for ECMO. The number of ECMO runs in NSW has increased almost three-fold in the past five years, from 45 in 2013–14 to 124 in 2018–19.\* It is anticipated that demand for ECMO will continue to grow.

\* An ECMO run is considered the time from a patient being initiated on ECMO with cannulation, to the time ECMO is ceased with decannulation

Internationally, V-A ECMO use is increasing for cardiogenic shock following cardiac surgery. There is heightened interest in using the technology in extracorporeal cardiopulmonary resuscitation (ECPR), although mortality rates, particularly for out-of-hospital cardiac arrest, remain high.

It is well established that rigorous patient selection and careful attention to potential complications are key to optimising patient outcomes in ECMO services. For example, seamless patient transport and clearly defined pathways for transition of care to higher level facilities that specialise in durable ventricular assist devices or heart and lung transplantation, allow for a coordinated system-wide service.

In NSW, the formalising of the ECMO retrieval service to become an ECMO Advisory Service is proposed. Its role will be to provide advice to clinicians across the state in the management of severe respiratory and cardiac failure, which may be indications for ECMO support. The service will also provide advice and support to clinicians in low - and intermediate-volume centres (less than 20 per year), as requested. Contributors to this advisory service are currently supported by clinicians at RPAH and St Vincent's hospital; in the future clinicians from other high-volume centres could also contribute to the service.

It is recommended that an ECMO advisory group be established with representation from units who currently provide ECMO. Invitees from referring sites would also be included. This will be organised through ICNSW at the Agency for Clinical Innovation. This group will determine an agreed dataset to monitor ECMO service provision across NSW in both adult and paediatric ICUs. The eight adult ICUs and two paediatric ICUs that currently provide ECMO support will be requested to submit agreed data to the ICNSW data manager on a three-monthly basis. Terms of reference will include ongoing monitoring of volume and outcome relationships, conducting regular state-wide case review and provide recommendations to the ICNSW Executive and the Critical Care Governance Committee from the Ministry of Health.

# ECMO services for adult patients

# Contents

Introduction	6
Structure and organisation	7
Protocols and procedures	9
Team composition, roles and responsibilities	10
Workforce education and training	11
Governance and leadership	13
Special considerations for ECPR service	14
References	15
Glossary	16
Acknowledgements	17

# Introduction

Extracorporeal membrane oxygenation (ECMO) is a high-risk, complex and resource intensive therapy. It plays a pivotal role in providing lifesaving respiratory and circulatory support for selected patients.

In NSW, ECMO services are provided in eight ECMO capable ICUs at the following hospitals:

- Royal Prince Alfred Hospital
- St Vincent's Hospital
- Liverpool Hospital
- Westmead Hospital
- Prince of Wales Hospital
- St George Hospital
- Royal North Shore Hospital
- John Hunter Hospital.

These are tertiary centres with cardiothoracic surgical units where clinicians with expertise in ECMO are available to support the initiation, ongoing management and post-ECMO patient care. NSW has a well-established ECMO retrieval service which has been operational for more than 10 years and supported by clinicians on a dedicated roster.

This model of care has been informed by an ACI clinical guide, which outlines key areas of ECMO practice, including:

- indications for ECMO and patient selection
- retrieval for ECMO services
- ECMO initiation
- ECMO maintenance
- ECMO weaning
- complications
- the use of ECMO in extra corporeal pulmonary resuscitation (ECPR).

The evidence for this model of care was drawn from consensus statements and recommendations; published by the Extracorporeal Life Support Organization (ELSO) and other jurisdictions, including Safer Care Victoria; research literature; and from local experts gathered through a structured process.<sup>3,4</sup>

The NSW adult ECMO model of care aims to ensure patients receive appropriate care at the right time and place.

## ECMO model of care five core principles

### Structure and organisation

Where timely and appropriate access to ECMO is coordinated across the NSW healthcare system.

### Protocols and procedures

This is such that patients receive timely care from clinicians who are supported by standardised, evidence-based protocols and procedures.

### Appropriate team composition

ECMO relies on a multidisciplinary team. The roles and responsibilities of team members require clear definition in a coordinated service.

### Workforce education and training

Education and training will ensure ECMO is delivered to patients in a safe and effective way.

### Governance and leadership

This is so patients receive high-quality care, underpinned by sound governance structures and clinical leadership.

# Structure and organisation

Timely and appropriate access to ECMO is coordinated across the NSW healthcare system.

The minimum acceptable case volume for an ECMO site is not clearly defined. An analysis of ELSO registry data from 290 ECMO sites show an inverse linear relationship between case volume and mortality, with sites performing more than 30 adult ECMO cases per year recording lower mortality than sites performing fewer than six cases per year.<sup>5</sup> One study supports these findings by stating that higher ECMO case volume at a given hospital is associated with lower in-hospital mortality, suggesting that referral to high-volume ECMO sites may lead to improved outcomes, however volume is not the only contributory factor to good outcomes.<sup>6</sup>

Initiation of ECMO by cannulation may be performed by either the originating hospital or the receiving hospital at the time of transport, depending on the capabilities of each site. Sites initiating ECMO should have surgical services immediately available that can manage the potentially life- or limb-threatening vascular and haemorrhagic complications of cannulation.

Across NSW, there are varying levels of ECMO service capabilities. Some sites are capable of initiating and maintaining patients on ECMO, some are capable of initiating ECMO only, while others do not have the services to provide ECMO at all. The following table describes the overall structure required for ECMO service delivery and the minimum capability requirements for sites to be capable of initiating and maintaining ECMO.

## Overall structure

ECMO advisory service with ECMO specialists on dedicated roster to provide advice on management of patients with severe respiratory and cardiac failure, who may be appropriate for ECMO.

Lower volume centres develop clear agreed guidelines for escalation and referral of patients to higher volume centres.

Referral to centres capable of providing long-term cardiac support therapies should be done via the ECMO Advisory and Retrieval Service.

Agreed institutional criteria for ECMO therapy including indications and contraindications, separation and weaning.

Developed guidelines for transfer of suitable ECMO patients to an ECMO-capable centre.

Adapted from: Safer Care Victoria, 2020.<sup>4,7</sup>

### Minimum capability requirements for ECMO-capable site

Coronary angiography suite and high-volume interventional angiography service and emergency ST-elevation myocardial infarction (STEMI) management capability available 24 hours a day, seven days a week.

Operating theatre and cardiothoracic services with vascular capability.

ICU with Fellow of College of Intensive Care exclusively on-call ECMO, with 30 minutes response time.

Emergency department with fellow of Australasian College of Emergency Medicine exclusively on-call ECMO, with 30 minute response time, 24 hours a day, seven days a week.

Accredited nursing staff capable of delivering safe and effective ECMO patient care according to local requirements.\*

Appropriate and adequate equipment available.†

Blood bank and pathology services available 24 hours a day, seven days a week (including off site).

Ultrasound trained and accredited critical care clinicians available 24 hours a day, seven days a week.\*

Interventional radiology service with reporting available 24 hours a day, seven days a week.

Ultrasonography machine with linear (vascular) and phased array (cardiac) probes, with doppler capabilities.

Telehealth facilities available

Adequate lighting to support surgical interventions  
Essential power or uninterrupted power system for all equipment, including mobile equipment, monitors and pumps for at least 45 minutes.

Adapted from: Safer Care Victoria, 2020.<sup>4,7</sup>  
(NSW Clinician consensus)

### Equipment and facilities needed in an ECMO unit

Minimum two ECMO pumps.

Backup components for the ECMO system and supplies for all circuit components.

Surgical instruments for revision of cannulae or exploration for bleeding complications.

Equipment for intrahospital transport.

Mobile ECMO trolley.

Mobile ECMO monitoring device.

Emergency transport backpack with clamps and emergency drugs.

Wet-primed circuit available for immediate use recommended.  
ECMO circuit water heater.

Monitoring device to assess distal perfusion of cannulated limbs, e.g. vascular doppler ultrasound, near-infrared spectroscopy (NIRS).

Fibreoptic bronchoscope.

Drawn from: Abrams et al, 2018<sup>5</sup>, Safer Care Victoria, 2020<sup>7</sup>

\* refer to education and training section

† refer to Equipment and Facilities needed in an ECMO unit

# Protocols and procedures

Patients receive timely care from clinicians who are supported by standardised, evidence-based protocols and procedures. The ECMO clinical practice guide and ECMO (extra-corporeal membrane oxygenation) Services in NSW, documents will assist in the further development of these.

ECMO capable centres must have protocols and procedures in place that are regularly reviewed by appropriate hospital committees. Protocols and procedures should include:

- indications and contraindications for ECMO
- clinical management of the ECMO patient
- transfer and retrieval of ECMO patients
- education and training program to credential medical and nursing staff
- maintenance of ECMO equipment
- weaning and separation from ECMO
- quality and safety mechanisms to include regular ECMO morbidity and mortality reviews and/or methods of connecting with other local health districts to review these.

# Team composition, roles and responsibilities

ECMO relies on a multidisciplinary team. A framework is provided below for staff roles and responsibilities. Other models may be developed when considering local expertise. Some procedures, such as cannulation, may be appropriately undertaken by cardiothoracic or vascular surgeons at some institutions. It is important to have clear and agreed roles and responsibility for a well coordinated service.

## Staff roles and responsibilities<sup>7,8</sup>

### ECMO intensivist

Responsible for:

- patient selection, assessment of and decisions regarding all patients requiring ECMO
- cannulation and optimal cannula configuration
- daily review of all patients on ECMO
- providing medical advice to ECMO and multidisciplinary team
- all key decision making e.g. weaning, anticoagulation and bleeding management, antimicrobial therapy and withdrawal of therapy
- technical and logistic support for ECMO retrieval
- providing attendance to assess and support any intra-hospital and/or inter-hospital transport of patients on ECMO
- the supervision of trainees.

### Nursing staff

All patients on ECMO must be cared for by a registered critical care nurse who is trained in the care of patients on ECMO. Twenty-four hour bedside ECMO nursing is required to:

- coordinate all aspects of patient management in collaboration with the multidisciplinary team
- maintain a safe environment for the management of a critically ill patient with a wide range of complex care needs
- ensure the safe monitoring, documentation, troubleshooting and management of the ECMO circuit, including immediate management of circuit emergencies.

### Cardiac anaesthetist (or similarly ECMO trained clinician) – along with the ECMO intensivist

Responsible for:

- assessment and decision support for all patients referred for ECMO
- support during cannulation and choosing optimal cannula configuration
- providing medical advice to ECMO and multidisciplinary team
- provision of anaesthetic support for any patient on ECMO requiring any operative intervention.

### Perfusionist

Responsible for provision of 24-hour on call cover for ECMO circuit support for the following, if needed:

- ECMO circuit priming
- cannulation
- decannulation
- intra- and inter-hospital transport of patients on ECMO
- mobilisation of patients away from the bed space
- movement of patients between ICU bed spaces
- circuit interventions, including circuit changes or circuit reconfigurations
- circuit management for all procedures away from the ICU.

### Social work services

Social work services are essential to assist patients and families with emotional support and unfamiliar processes such as:

- travel
- parking
- accommodation
- unplanned management of the patient's personal affairs.

# Workforce education and training

Education and training ensures ECMO is delivered to patients in a safe and effective way.

The minimum requirements for training and experience required to become part of an ECMO team varies between centres and countries.

ECMO staff should receive regular training and education on theoretical and practical aspects of ECMO, including simulation training. More simulation training is recommended for staff who handle a lower volume of ECMO cases. Participation of staff in this education program should be recorded and their proficiency evaluated, and retraining of team members as needed and according to criteria set out by the ECMO program.<sup>5</sup> The following requirements are largely adapted from the Royal Prince Alfred Hospital guidelines, which were adapted from the findings of the International Survey on Extracorporeal Membrane Oxygen Transport and current standards of practice at other intensivist-lead ECMO centres, including The Alfred Hospital.<sup>9</sup>

NSW ECMO specialists recognise that each ECMO capable centre should set a minimum amount of ECMO experience for members of the ECMO team to maintain competency. Access to an advanced ECMO course should be available to all staff involved in the care of a patient on ECMO.

## Recommendations for NSW Clinicians

### Cardiac anaesthetists

Cardiac anaesthetic who participate in an ECMO service should be trained in:

- ECMO circuit setup
- troubleshooting
- physiology
- patient management
- proficient in transoesophageal echocardiography (TOE) during ECMO cannulation.

### ECMO intensivists

To be considered competent and independent in ECMO cannulation and management of patients on ECMO, it is recommended that intensive care specialists be credentialed in the following.

#### Cannulation

- Achieving competence: 5–10 supervised human cannulations
- Maintain competency by ongoing cannulation and simulation training yearly
- Ongoing independent practice:
  - continual involvement in cannulation for those in high-volume centres, or monthly/bi-monthly simulated cannulation drills for those in lower-volume centres
  - continual involvement in managing circuits for those in high-volume centres, or monthly/bi-monthly wet circuit water drills for those in lower-volume centres.

#### Retrieval

- Three supervised retrieval transports
- Maintain three retrievals per year for competence.

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**ECMO care day-to-day**

- ICU specialist who has completed an appropriate accredited ECMO course
- Demonstrated commitment to continued learning and staying abreast of best practice methods and guidelines
- Participation in multidisciplinary team quality assurance projects and activities.

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**NSW ECMO clinicians also suggest (minimum)**

- Prerequisite essentials skills such as advanced life support
- Be a permanent member of staff
- Introductory eight-hour multidisciplinary workshop (didactic and practical simulation)
- Focus on each aspect of initiation, cannulation and management
- Two supernumery days for nursing staff at the bedside post-workshop
- Complete a learning package and competency assessment, as appropriate
- Keep a registry of registered and certified staff
- Acknowledge recognised prior learning (RPL)
- Multidisciplinary simulations and debrief
- Preceptorship
- Eight-hour workshop on initiation, cannulation, management and troubleshooting for medical officers.

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**ECMO ICU registered nurses**

Intensive care nurses provide care for patients receiving ECMO and are trained to manage ECMO circuit and pump as specialists.

Adequate nursing staff need to be trained to manage patients receiving ECMO support. For example, an ECMO run of around 10 days requires 20 twelve-hour nursing shifts. This means a roster of at least 10-12 intensive care nurse ECMO specialists, as well as additional support staff, are needed to manage the patient.

Centres with capacity to manage 20-30 patients per year and up to three patients simultaneously, should credential and be able to maintain at least 40 nursing full-time positions at the ECMO specialist level.

Initial training for ICU registered nurses to be deemed competent in the day-to-day care of ECMO patients includes:

- completion of an ECMO course, with associated learning packages, pre-workshop readings or similar
- preceptorship at the bedside with an ECMO accredited clinician.

Additionally, nursing levels should be such that the provision of care to a patient newly established on ECMO or during times of instability, can be achieved safely and efficiently. This will often require more than one nurse to care for these patients during this time.

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# Governance and leadership

Patients receive high-quality care, underpinned by sound governance structures and clinical leadership.

- Formal governance arrangements are documented and endorsed by individual units
- The ECMO model for adult patients has local executive sponsorship and oversight, and local implementation support
- An ECMO coordinator has a key role in ensuring appropriate supervision and training, quality assurance, policy and procedures
- Clinical roles and responsibilities are clearly defined and documented, including scopes of practice and interdependencies between referral sites, ECMO capable centres and the retrieval teams
- Roles and responsibilities are clearly defined for the various steering and operational committees and groups, management, clinicians and the workforce
- Care delivery is regularly reviewed against clinical pathways and protocols
- Regular local multidisciplinary morbidity and mortality meetings and ICNSW ACI ECMO Advisory Group meetings. Results of audit, incident reporting, and agreed data set and ECMO KPIs fed back to the multidisciplinary team for quality assurance review
- Development of a risk register at ECMO capable sites which is maintained and reviewed as part of local processes with escalation of risks
- Contribution to state ECMO Advisory Group at ICNSW/ACI meetings
- Formal clinical case reviews, with a multidisciplinary approach at local and state levels, should be conducted regularly to implement identified improvements for patient care across NSW ECMO centres
- ECMO centres should contribute to large national or international registries for clinical audit and benchmarking. This allows a comparison of outcomes and to highlight variation in practice<sup>5</sup>
- An agreed data set should be submitted to the ICNSW ECMO Advisory group
- Developing and maintaining a culture of improvement with quality and safety processes, initiatives and research.

## Special considerations for ECPR service

The use of ECMO to restore circulation during cardiac arrest, referred to as extracorporeal cardiopulmonary resuscitation (ECPR), presents unique challenges.

Unlike progressive, severe cardiogenic shock, which most often occurs in the cardiac catheterisation laboratory, intensive care unit or operating room cardiac arrest may occur unpredictably in any location throughout the hospital, including the emergency department, where ECPR programs have been under development.

The decision of whether to initiate ECMO and cannulation must be executed as quickly as possible, ideally with the use of pre-specified criteria to identify patients who are likely to benefit from this intervention.

ECPR within NSW is actively under review, with research into this area of extracorporeal support currently being undertaken by ECMO clinicians in collaboration with NSW Ambulance. ECPR should only be used in clinical trials until there is sufficient evidence to establish clinical effectiveness.

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# Glossary

ARDS	Acute respiratory distress syndrome
CA	Cardiac arrest
CPR	Cardio-pulmonary resuscitation
ECCO2R	Extracorporeal membrane carbon dioxide removal
ECMO	Extracorporeal membrane oxygenation
ECLS	Extracorporeal life support
ELSO	Extracorporeal Life Support Organization
EXCEL	An ECMO national registry on the treatment and outcomes of patients requiring ECMO supported by the Australian and New Zealand Intensive Care Research Centre, Monash University
IHCA	In-hospital cardiac arrest
ICU	Intensive care unit
Low-flow time	Duration between commencement CPR until ECMO has reached full flow support
mCPR	Mechanical cardio-pulmonary resuscitation
MOF	Multi organ failure
NICE	National Institute Clinical Excellence
No-flow time	The time between the moment a person collapses until CPR commences
OOHCA	Out-of-hospital cardiac arrest
PaO <sub>2</sub>	Partial pressure of oxygen
PaCO <sub>2</sub>	Partial pressure of carbon dioxide
ROSC	Return of spontaneous circulation
RPAH	Royal Prince Alfred Hospital
TAH	Total artificial heart
VAD	Ventricular assists devices
V-A ECMO	Venoarterial extracorporeal membrane oxygenation
V-V ECMO	Venovenous extracorporeal membrane oxygenation

# Acknowledgements

## Authorship

The Agency for Clinical Innovation (ACI) Intensive Care NSW Network led the development of this document, in consultation with members of the NSW advisory committee adult ECMO and approved by the Intensive Care NSW executive group.

The Agency for Clinical Innovation (ACI) is the lead agency for innovation in clinical care.

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