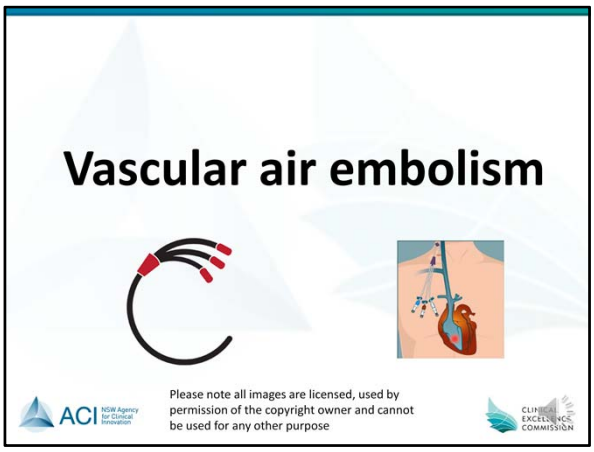
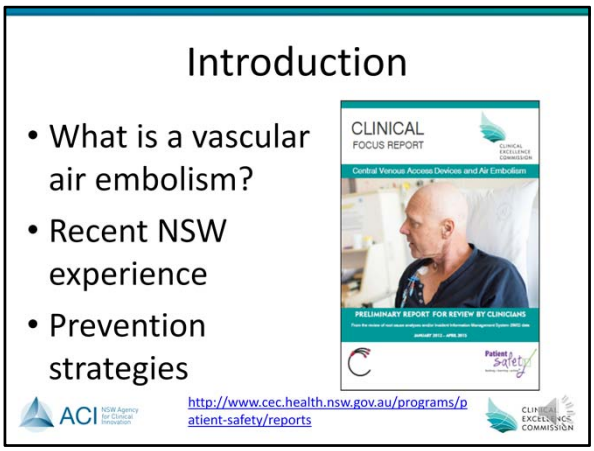


This presentation was developed to assist local clinician with delivery of education regarding vascular air embolism



Gerry a 50 year old male was sitting in a chair and had been in ICU for 6 days after extensive surgery.
He was well enough to transfer to the surgical ward that day but needed his lines removed prior to transfer.

The patient didn't want to go back to bed and asked if he could stay in the chair. The nurse did not want to upset the patient leading to prioritising the perceived minimal patients discomfort over the risk of removal in a semi recumbent position.
Gerry leaned back in the chair and the line was removed after instructing him to breath in and hold his breath.
It was reported that Gerry had no symptoms such as respiratory compromise directly after removal.
Pressure to the site and an occlusive dressing was applied.

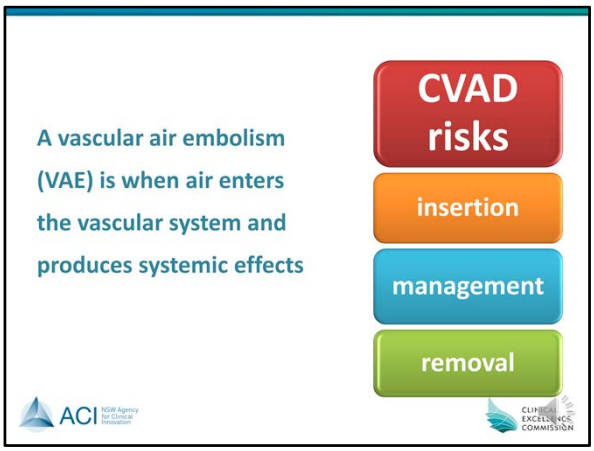
About 10 minutes later the patient was found unresponsive.

The initial cardiac rhythm was sinus tachycardia with self limiting runs of VT. There was agonal breathing and his blood pressure was recorded as 85/40 and his pupils were equal with bilateral downward gaze. His GCS was recorded as 6/15.

Gerry required intubation and an arterial line was inserted. A TOE was performed which showed a hyperdynamic left ventricle and air bubbles present. A later MRI showed extensive infarcts. Gerry died 3 days later.

In NSW it is difficult to accurately ascertain the number of CVAD used. But it is estimated that 15000 CVADs are inserted in ICU yearly.

It is acknowledged that CVAD use can be associated with risks. The increased usage of CVAD has potentially led to an underestimation and normalisation of the potential risks associated with their use. There has been a gradual shift in the boundaries of safe practice, with these deviations becoming accepted as routine or normal practice with acceptance of these suboptimal practices.

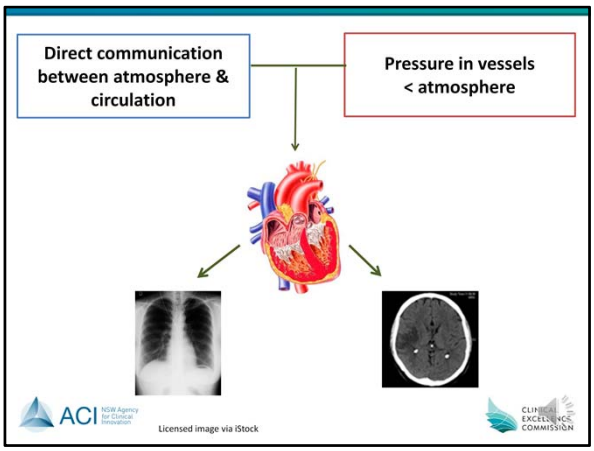


An vascular air embolism is when air enters the circulation and may be venous or arterial. It can produce systemic effects such as cardiopulmonary arrest, anoxic encephalopathy or death.

Vascular air embolisms from central venous access devices (CVADs) is a preventable patient safety event. It can occur at any point across the spectrum of CVAD care, including on insertion, during day to day management of the line and especially on removal

The true incidence of VAE is unknown as the patients symptoms may be transient and can be attributed to the patients underlying condition rather than related to CVAD management.

The temporal relationship between a patient's sudden deterioration, inclusive of respiratory, cardiac and neurological, and the insertion, removal or routine care of a CVAD, should prompt clinicians to have a high index of suspicion of a relationship between the two events



For an air embolism to occur there must be a direct communication between the atmosphere and the circulation AND
Importantly the intravascular pressure must be less than atmospheric pressure to draw air in

Once the air enters the vascular system commonly it moves to the right side of the heart and may accumulate and then be circulated into the pulmonary vessels .

It is estimated that 20-25% of the population have a patent foramen ovale. This places those persons at greater risk of a serious outcome.

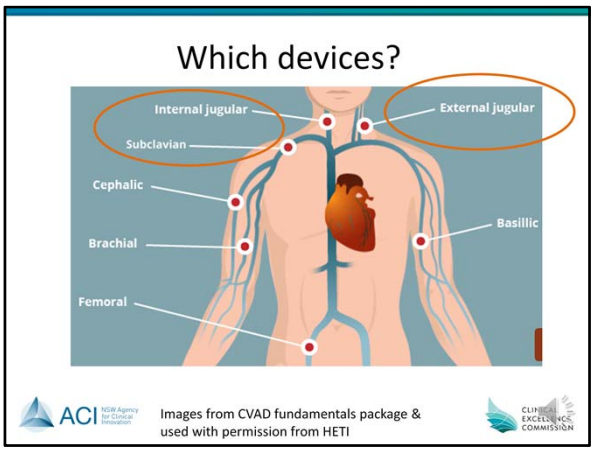
The rate and volume of air that enters the vascular system will depend on
1. Lumen size of access device
2. The presence of a pressure gradient which favours air entry into the circulation
3. A direct communication or tract between the atmosphere and the venous or arterial circulation

The pathophysiological effects depends on the rate and volume of air accumulation this is influenced by
1. Position of the patient
2. Volume and rate of gas entrainment
3. Site of the CVAD in relation to the heart
4. The end anatomical location of where the air ends up.

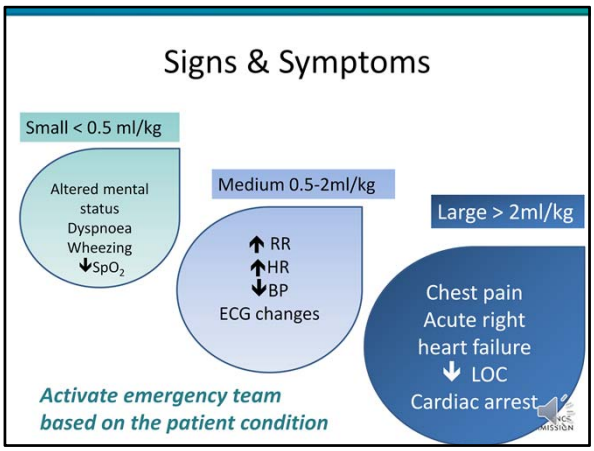
With small to moderate air emboli (that is between 0.5 to 2 ml per kg) signs and symptoms maybe more subtle and could be missed.

A large VAE, that is the rapid absorption of more than 2mls/kg, may result in a gas-air lock where the right ventricule is unable to compress, leading to deterioration and collapse.

Regardless of symptoms a VAE should be considered in any patient who has or had a CVAD, especially where there has been recent manipulation of the CVAD or patient movement



While any CVAD has the potential to allow air to enter the vascular it is more likely to occur through a non-tunnelled centrally inserted central venous catheters.



There are a number of sign and symptoms that may indicate that a vascular air embolism has occurred.

For smaller VAE symptoms may include

- Altered mental status, dyspnoea, oxygen desaturation and wheezing

As the volume of air increases so do the symptoms

- Increasing breathlessness, hypotension, ECG changes
    - ST changes, peaked p waves,
    - Jugular venous distension

Larger volumes can lead to

- Chest pain, acute right heart failure, decreasing level consciousness and cardiac arrest

Clinicians should activate local clinical emergency response systems depending on the severity of the patient's symptoms and local escalation systems.

In NSW health it was identified that there could be a problem with CVAD related air embolism.

A review was undertaken looking at incidents notified during January 2012 to April 2015.

Incident information was sourced from the incident information management system using word searches and from root cause analysis investigations reports.

It was identified that there had been 14 actual vascular air embolism events and 51 near miss events.

Of the 14 events 6 patient died as a result of an vascular air embolism.

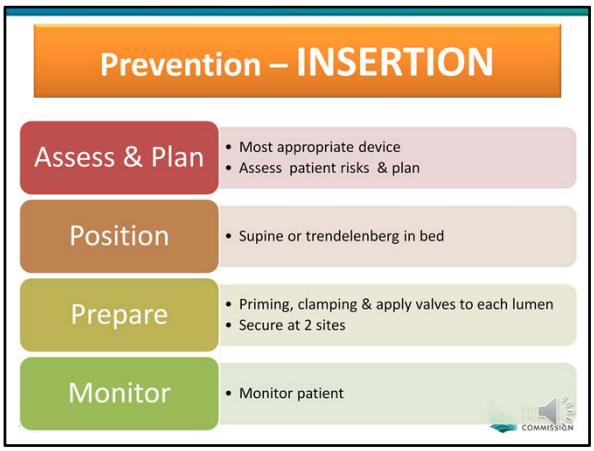
Looking at the circumstances of each of the 14 events
3 occurred during insertion with 1 death
9 occurred during removal with 4 deaths
2 occurred during routine care and resulted from disconnections of the line – resulting in 1 death

9 of the incidents occurred within critical care areas

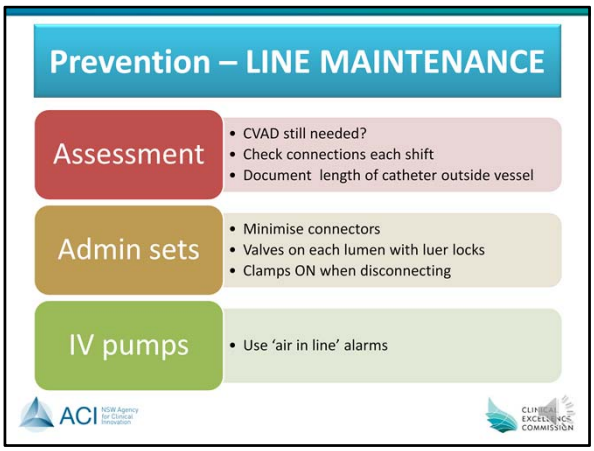
Looking further at the circumstances of each of the events it was ascertained that 7 of the 9 (78%) removal events occurred with the patient either in a sitting or semi recumbent position.

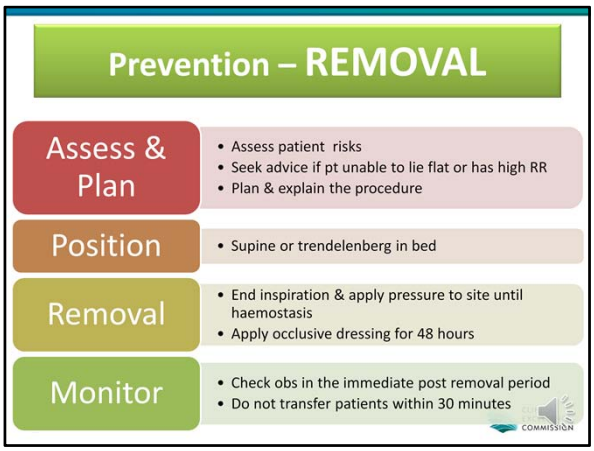
Most of the CVAD were in the internal jugular.

From a patients perspective there were also some commonality of patient features.
40% of patients had a respiratory history
40% had a low BMI
33% had an admission reason related to gastrointestinal issues e.g. SBO making it possible that they may have been intravascularly depleted.
All of these 3 factors are cited in the literature to put patients more at risk of an vascular air embolism.



To reduce and prevent adverse events CVADs should only be managed by trained clinicians or by novices under the direct supervision of these clinicians


Prevention – LINE MAINTENANCE
Assessment
• CVAD still needed?
• Check connections each shift
• Document length of catheter outside vessel
Admin sets
• Minimise connectors
• Valves on each lumen with luer locks
• Clamps ON when disconnecting
IV pumps
• Use 'air in line' alarms
ACI



To reduce and prevent adverse events CVADs should only be removed by trained clinicians or by novices under the direct supervision of these clinicians
Removal of a CVAD is a aseptic procedure.

Assess & plan

- Before removing the catheter the clinicians should assess patient risks then PLAN and EXPLAIN the procedure to the patient.
- Particular risks include
    - the patient cooperative or understands
    - Is breathless & or unable to lie flat for an extended period as well as hold their breath while the line is removed
    - Dehydration
    - Sweaty patients
    - Local site infection that may scaffold the vessel open

- Where the patient has limited ability to lie flat for the time required seek medical advice
- or their cooperation or understanding is not ideal, an assistant should be considered
- Equipment should be positioned so that the clinician who is removing the line is able to remove the line with one hand and to apply pressure with the other one for an extended period. Ideally this would be next to the insertion site (commonly at head of the bed)
- If the catheter tip is required ensure there is a sterile area on the dressing trolley where the catheter can be placed after removal

Position

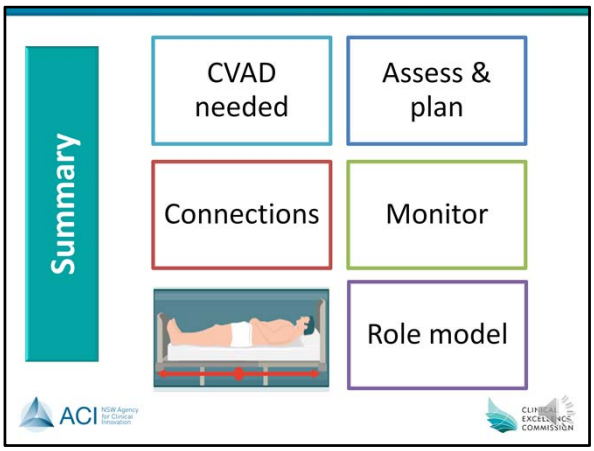
- As with insertion it is vitally important that the insertion site of the catheter is below the right ventricle when the catheter is removed. This will ensure that the pressure in the blood vessels is higher than atmosphere, thus preventing air entry
- This is best achieved by the patient being in bed and positioned supine or in trendelenburg

Removal

- Before removal of the line get the patient to practice holding their breath for the time it takes to pull the catheter out.
- If this is not possible remove during quiet breathing
- After appropriate preparation (including clamping of catheter lumens, cleansing of site and removal of sutures & or securement device)
    - hold a folded gauze square firmly over the insertion site, get the patient to take a breath in and hold it
    - Pull gently and continuously on the catheter ensuring that the pressure applied to the site compresses the blood vessel. Discard the catheter WHILE keeping pressure on the site

    - Be alert for any deterioration in the patients condition indicating a possible embolus
    - DO NOT attempt to apply pressure to the site AND obtain a catheter tip at the same time
    - This will distract you from applying pressure to compress the vessel appropriately so that air cannot enter and haemostasis is achieved.
- After haemostasis is achieved an occlusive dressing must be applied and kept in place for 48hrs

Monitor



CVAD needed?
Central venous access devices put the patient at risk and clinicians must check on a daily basis that the CVAD is still required & functional

Assess and plan
Clinicians should assess and plan any CVAD procedures, in particular where the patients are at increased risk such as patients with limited understanding, may be uncopoerative or have limited respiratory reserve so that they are unable to lie flat or hold their breath during removal

Connections
Any Connections to the catheters can become disconnected and should be minimised
Were they are used they should be Luer lock and assessed at least each shift to ensure they are appropriately tight

Monitor
After any procedure related to the CVAD clinicians should monitor the patients condition and be mindful and any deterioration, especially where this might indicate a vascular air embolism

Position
An important prevention strategy is that the catheter be inserted and removed while the patient is in bed and positioned supine or in trendelenburg. This ensures that the insertion site is lower than the right ventricle and the pressure within the blood vessel is higher than atmosphere thus preventing the absorption of air in the circulation

Role model
Clinicians, especially novices, mimic the clinical behaviours they observe. Therefore it is important that all staff role model best practice demonstrating to everyone what are acceptable clinical behaviours.

CVAD Training Information

HETI code	Name of course
92712530	Central Venous Access Devices: the Fundamentals – e learning module
92382298	CVAD Intravenous (IV) Administration Set Change Assessment Tool
92381360	CVAD Dressing and Swabable Capless Valve (SCV) Change Assessment Tool
92382007	CVAD Removal of Non- Tunnelled Assessment Tool
96342016	Vascular Air Embolism PODCAST (link out)
N/A	ACI -CVAD Training resources: http://www.aci.health.nsw.gov.au/networks/intensive-care/clinicians/ic-manual/cvad
N/A	Central Line Insertion NSW Health staff link http://edmoretraining.com.au/doh/ External link via CEC Website http://cec.health.nsw.gov.au/concluded-programs/clab-icu/cli-training/cli
N/A	Central Line Insertion Training Framework http://www.cec.health.nsw.gov.au/__data/assets/pdf_file/0005/258350/training-framework.pdf

ACI NSW Agency for Clinical Innovation

HETI Collaboration Openness Respect Empowerment

CLINICAL EXCELLENCE COMMISSION

NSW Health

- Report CEC http://www.cec.health.nsw.gov.au/programs/patient-safety/reports
- Safety notice 002/15 http://internal.health.nsw.gov.au/quality/sabs/pdf/2015-sn-002.pdf
- Safety notice 004/14 http://internal.health.nsw.gov.au/quality/sabs/pdf/sn004-14.pdf
- PD2011_060 http://www0.health.nsw.gov.au/policies/pd/2011/pdf/PD2011_060.pdf
- ACI Guideline http://www.aci.health.nsw.gov.au/networks/intensive-care/clinicians/ic-manual/cvad

Further reading

- Pennsylvania Patient Safety Authority Reducing Risk of Air Embolism associated with Central Venous Access Devices 2012: http://patientsafetyauthority.org/ADVISORIES/AdvisoryLibrary/2012/Jun;9(2)/Pages/58.aspx
- Mirski MA (2007) Anaesthesiology 106(1): 164-177
- Pinho J (2016) Journal of the Neurological Sciences. 362, p.160-4.

Case Studies

- **Vascular air embolism**
  http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3665124/
- **A Patient With Acute COPD Exacerbation and Shock**
  http://journal.publications.chestnet.org/article.aspx?articleid=1775337

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Clinical Excellence Commission

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