Worcestershire Acute Hospitals NHS Trust

Guidelines for Acute Respiratory Failure

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Key Amendments

Date	Amendment	Approved by
8th October 2019	Document extended with no changes as part of Disease Management section in critical care	Dr Nick Cowley/Dr Andy Burtenshaw
13TH March 2020	Update to guide management of COVID-19 patients	Dr Nick Cowley/Dr Andy Burtenshaw
14th October 2022	Document reviewed with no changes	Intensive Care Forum/ SCSD Governance

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Modified for use within Worcestershire Acute Hospitals NHS Trust by Dr G P Sellors and Dr a Burtenshaw

RECOMMENDATIONS FROM FACULTY OF INTENSIVE CARE MEDICINE

Authors: Mark Griffiths & Gavin Perkins

Local interpretation: by Dr G P Sellors and Dr A Burtenshaw

1) All patients with, or at risk of, acute respiratory failure (ARF) requiring mechanical ventilation should be subjected to a lung protective ventilation strategy using low tidal volumes and airway pressures.

   Charts of predicted body weight and ventilator volume range are given at Appendix 1. These charts are attached to the Drager Evita ventilators used throughout the county.

2) Patients with moderate to severe ARDS may benefit from the application of high positive end expiratory pressure (PEEP) and from prone positioning for at least 12 hours per day.

3) The use of neuromuscular blocking agents in patients with ARDS for the first 48 hours of mechanical ventilation may improve outcome by mitigating ventilator-patient dysynchrony and thereby ventilator associated lung injury.

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4) Patients with severe but potentially reversible ARF who cannot achieve adequate gas exchange with protective ventilatory settings, should be discussed with the Heartlink ECMO Centre at Glenfield Hospital, Leicester on telephone number **0300 300 3200**.

5) The role of extra-corporeal carbon dioxide removal ($ECCO_2R$) in patients with ARF has not yet been defined, but this support may help to mitigate the adverse effects of mechanical ventilation in patients with ARDS and obstructive airways diseases (e.g. asthma and chronic obstructive pulmonary disease [COPD]).

   WRH ICCU has considerable clinical experience with $ECCO_2R$ in the context of patients with potentially reversible hypercarbic respiratory failure. The use of $ECCO_2R$ within Worcestershire Acute Hospitals NHS Trust is dealt with in a separate guideline.

6) Within Worcestershire, rescue plans for refractory hypoxaemia include recruitment manoeuvres, airway pressure release ventilation (APRV) and inhaled prostacyclin. It is acknowledged that these strategies do not improve the outcome of unselected patients with ARDS.

   Following the ICM Forum on the 6th May 2015 HFOV is no longer available within the Worcestershire Intensive Care Units.

7) Non-invasive ventilation has an established role in providing respiratory support for patients with acute exacerbations of COPD and early ARDS.

8) An active fluid management strategy targeting neutral or negative fluid balance may benefit respiratory recovery in patients with ARDS without compromising the function of other organs.

BACKGROUND

ARF has multiple causes, which may affect the lungs directly (e.g. pneumonia and COPD) or indirectly as part of the multi-organ dysfunction syndrome (e.g. sepsis syndromes). Treatment depends on the underlying causes, but because these may not be immediately obvious, a robust diagnostic approach is required.

In the absence of disease-modifying therapies for ARF, the mainstay of ARF management is to provide respiratory and other organ support whilst causing minimal harm.

The Berlin definition for ARDS distinguishes ARDS into mild, moderate and severe categories on the basis of the severity of impairment of oxygenation (PaO2:FiO2 ratio of <300, <200 and <100 mm Hg respectively)[1].

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Ventilatory strategies

Meta-analysis of 20 observational studies and control groups from randomised controlled trials which included 2,822 participants at risk of ARDS suggests that patients at risk of ARDS undergoing surgery or being ventilated in the intensive care unit have a lower risk of progression to ARDS and a reduced mortality rate if they receive protective ventilation strategies[2].

Meta-analysis of six randomised controlled trials involving 1,297 patients showed that the use of protective ventilation in patients with ARDS reduces early (28-day) mortality[3].

The use of high levels of PEEP in patients with ARDS has been evaluated in seven randomised trials (2,565 participants).

Compared to standard levels of PEEP, high PEEP improves oxygenation but has no effect on mortality or the risk of barotrauma[4]. An individual patient data meta-analysis from three of these trials suggests that patients with moderate or severe ARDS (P:F ratio < 200 mm Hg) may benefit from the application of higher levels of PEEP[5].

High-frequency-oscillation ventilation has been subject to six randomised controlled trials which enrolled 1,608 patients with ARDS.[6] Meta-analysis of the results of these trials showed that although HFOV improves oxygenation and does not seem to increase the risk of barotrauma or hypotension, it does not improve survival.

Non-ventilatory strategies

Pharmacological interventions evaluated to date have either had no overall effect (e.g. steroids) or have been shown to be harmful (e.g. beta agonists), and should not be used routinely.

Risk factors for the development of ARDS amongst patients at risk include blood transfusion, fluid overload and inappropriate initial antibiotic therapy. Careful consideration of the risks and benefits of these treatments should be considered on an individual patient basis.

For patients with established ARDS, the use of prone positioning has been evaluated in nine RCTs with 2,242 patients[7]. Prone positioning improved mortality, particularly in patients with severe ARDS. The effects were more pronounced when the duration of time spent in the prone position exceeded 12 hours.

A multi-centre randomised controlled trial evaluating the use of 48-hours neuromuscular blockade in patients with moderate to severe ARDS (P:F ratio < 150 mm Hg) improved mortality, increased ventilator and organ-failure free days, and reduced biotrauma without any difference in ICU acquired paresis[8].

A randomised trial of a conservative fluid strategy in 1,001 patients with established ARDS who did not have evidence of tissue hypoperfusion, led to fewer days of mechanical ventilation and reduced length of ICU stay, without altering the incidence of renal failure or mortality rates[9].

Referral of patients with potentially reversible, severe ARDS to a regional ECMO centre has been shown to improve mortality and is cost-effective10. A propensity-matched analysis of

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patients in the UK with severe ARDS due to H1N1 showed improved mortality amongst patients referred and transferred to a regional ECMO centre[10]. After the H1N1 2009 influenza pandemic, a network of five ECMO centres was commissioned to provide retrieval of, and advanced care for, patients with severe ARDS and ARF in England and Wales.

The mortality rate of ARDS remains at approximately 40% for unselected populations, although that of the control groups of multi-centre studies has decreased progressively to between 20-30%.

Chronic respiratory failure is a rare consequence of ARDS, but neuromuscular and psychological after-effects are common and are reflected in high levels of unemployment in survivors after hospital discharge[11].

Facilities to support rehabilitation during the recovery phase are recommended, as is follow-up in a specialist out-patient clinic after hospital discharge.

REFERENCES FOR FICM STANDARDS

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AIRWAY PRESSURE RELEASE VENTILATION

Definition:

APRV is a time cycled, pressure controlled mode of ventilation for spontaneously ventilating patients. It is characterized by relatively long periods of continuous positive airway pressure interrupted by regular, short, pressure releases. Unrestricted spontaneous breathing may occur throughout any part of the respiratory cycle.

Rationale:

APRV may be of particular use for patients with Acute respiratory Failure (ARF) or Acute Respiratory Distress Syndrome (ARDS).

Particular features which are thought to be of benefit include:

- Open lung approach to management of ARF/ARDS.
- Longer periods of time spent at the higher selected pressure allow areas of the lung with longer time dependent opening to be recruited.
- Intermittent pressure releases during APRV act to supplement spontaneous minute ventilation. These releases are short enough that they do not allow complete collapse of recruited alveolar sacs.
- Higher mean airway pressure (mPaw) than conventional ventilation. Higher levels of mPaw are directly correlated with lung volume and improvements in oxygenation.
- Avoidance of excessive peak airway pressures. High peak airway pressures are associated with barotrauma and worsening of the pulmonary pathological process. Excessive airway pressures are associated with increased mortality in ARDS.
- Spontaneous ventilation during APRV results in more dependent gas distribution than occurs with passive ventilation in conventional ventilatory modes. This may improve ventilation-perfusion matching with a consequent improvement in gas exchange. It may also result in preferential recruitment of dependent lung regions without the need for excessive airway pressures and may therefore avoid overdistension of non-dependent lung regions. Overdistension and high tidal volumes are also associated with increased mortality in ARDS.
- Because spontaneous ventilation is permitted throughout any part of the ventilator cycle, patients can often remain quite comfortable at relatively low levels of sedation. Reduced sedation requirements may have beneficial effects

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on cardiovascular function, and have been associated with reduced days spent on a ventilator, reduced likelihood of ventilator associated pneumonia (VAP) and fewer days spent in ITU.

- Concurrent spontaneous breathing during APRV has been shown to improve cardiac contractility as a result of augmentation of cardiac filling, and may also therefore reduce dead space ventilation.
- Avoidance of neuromuscular blockers is fundamental to APRV. Avoidance of these agents is associated with reduced incidence of critical illness neuropathy and myopathy.

Despite these potential advantages, it is important to recognize that current evidence demonstrates only that APRV is an effective mode of ventilation. No sufficiently large scale randomized controlled studies have taken place to evaluate its impact on outcome.
N.B. APRV is not recommended as a mode of ventilation for patients with COPD or asthma.

DETAILS OF GUIDELINE

The decision to use APRV and its initiation should only be made by a consultant intensivist or a senior trainee experienced in the use of APRV.

In addition to FiO_2, adjustable parameters are:

P_{High}	High CPAP level at which the majority of the ventilator cycle is spent
P_{Low}	Low CPAP level to which the time-cycled breaths are released
T_{High}	Time spent at P_{High}
T_{Low}	Time spent at P_{Low}

Initial settings:

The patient should not be paralysed and should be sufficiently lightly sedated that they are capable of spontaneous ventilatory effort.

Automatic Tube Compensation (ATC) should be set to 100% and the correct airway type and size selected.

STEP 1:

P_{High} Set equal to plateau pressure on previous conventional ventilation mode or 30 cmH_2O (whichever is lower)

P_{Low} Set to 0 cmH_2O

T_{High} 5 seconds

T_{Low} 0.5 second

FiO_2 1.0 or 0.2 greater than previous ventilator settings (for safety during initial transition to APRV from conventional ventilation)

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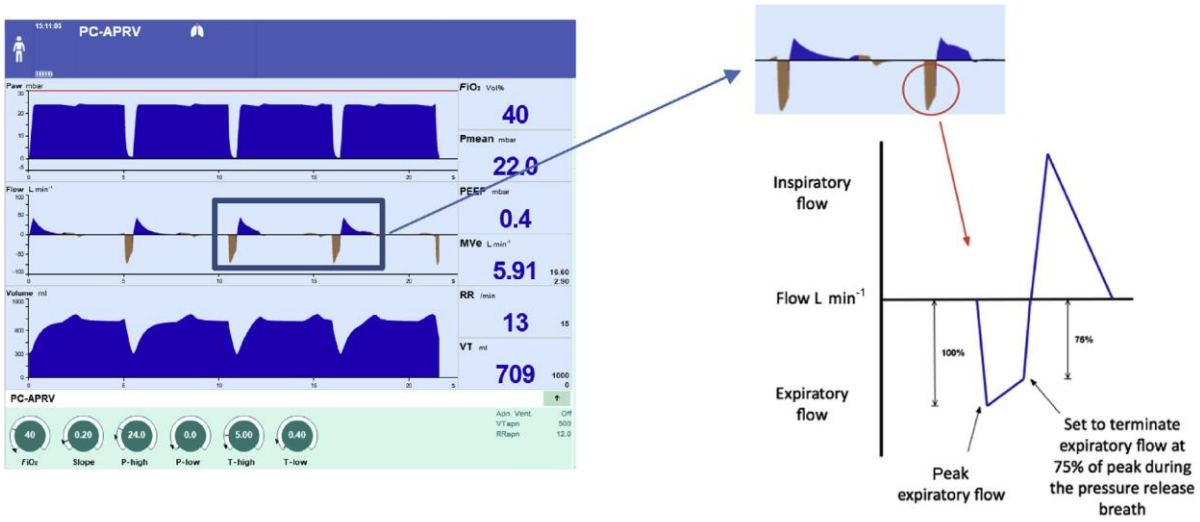
STEP 2:
Immediately assess flow waveform and release volumes. T_{Low} should be adjusted until the expiratory flow rate decays to 75% of the peak expiratory flow rate.



P_{Low} should usually remain set at zero cm H_2O.
T_{High} should then be adjusted, depending upon the established T_{low} settings, so that releases occur approximately 12-15 times per minute in the initial phase.

Physiological goals:

Maintain PaO2 ≥ 8.0 kPa
Maintain PaCO2 such that pH ≥ 7.20

Subsequent evaluation:

1. Strategies to improve oxygenation
    a. Increase F_iO_2
    b. Increase P_{High} in 2-5 cm H_2O increments to a maximum of 30 cm H_2O (Aiming to exceed threshold opening pressure (TOP) of non-recruited lung regions). Re-evaluate T_{Low} settings after any change in pressure settings.
    c. Increase T_{High} in 0.5-2 second increments to a maximum of 10 seconds
    d. Reduce T_{Low} in increments of 0.05-0.1 second to optimize end-expiratory lung volume
    e. Optimise haemodynamic status to ensure optimum pulmonary perfusion.
2. Strategies to improve CO_2 clearance
    a. Assess for oversedation (inadequate spontaneous ventilation)
    b. Ensure T_{Low} is set to allow decay of expiratory flow rate to ~75% of peak flow rate.

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c. If P_{High} < 30, increase in increments of 2-5 cm H_2O to a maximum of 30 cm H2O. Re-evaluate T_{Low} settings after any change in pressure settings.

d. Decrease T_{High} in increments of 0.5-2 seconds to increase the number of pressure releases per minute.

3. Evaluation of sedation

a. Spontaneous ventilation is an essential prerequisite to the success of APRV. Sedation should therefore be titrated to achieve a spontaneous ventilation rate resultant in a pH ≥ 7.20. This should usually be between 15 and 40 bpm.

4. Evaluation of lung recruitment

a. As the lung is progressively recruited release volumes will increase. T_{Low} should be re-evaluated at least every 1-2 hours in the first six hours after initiation of APRV to ensure that expiratory flow decay curves remain "clipped" at about 75% of peak flow rates.

b. Throughout longer therapy lung compliance will alter with changes in lung pathology. Re-evaluation of settings should take place regularly.

5. Weaning on APRV

a. Initially reduce P_{High} to maintain release volumes 6-8ml/Kg IBW

b. Progressively reduce FiO_2 to target ≤ 0.4 with SpO_2 ≥ 95%

c. Progressively wean by simultaneously reducing P_{High} (by increments of 2-5 cm H_2O) and increasing T_{High} (increments of 0.5-2 seconds) so that the minute volume generated by release volumes decreases and is gradually supplemented by increased spontaneous minute volume, until the patient has essentially been weaned to pure CPAP. Then convert to standard CPAP with low level pressure support and continue wean as usual.

6. Failure of APRV

a. If unable to achieve adequate oxygenation or carbon dioxide clearance despite above manipulations of therapy consider alternative ventilation strategies, or advanced interventions such as Extracorporeal CO_2 Removal ($ECCO_2R$).

b. Consideration should simultaneously be given to other physiological manipulations such as diuresis or exclusion of other compliance limiting pathologies (e.g. drainage of pleural effusions, ascites etc)

c. In the event of excessive release volumes despite appropriately timed releases, consider alternative ventilation modes.

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Appendix 1

Predicted body weight and ventilator volume range charts

Predicted body weight and ventilator volume range chart **FEMALE**

Non Acute Lung Injury			Height	PBW	Acute Lung Injury / ARDS		
6 ml/Kg	-	8 ml/Kg	(cm)	(Kg)	4 ml/Kg	-	6 ml/Kg
206	-	274	140	34	137	-	206
211	-	281	141	35	141	-	211
216	-	289	142	36	144	-	216
222	-	296	143	37	148	-	222
227	-	303	144	38	152	-	227
233	-	310	145	39	155	-	233
238	-	318	146	40	159	-	238
244	-	325	147	41	162	-	244
249	-	332	148	42	166	-	249
255	-	339	149	42	170	-	255
260	-	347	150	43	173	-	260
265	-	354	151	44	177	-	265
271	-	361	152	45	181	-	271
276	-	368	153	46	184	-	276
282	-	376	154	47	188	-	282
287	-	383	155	48	191	-	287
293	-	390	156	49	195	-	293
298	-	397	157	50	199	-	298
303	-	405	158	51	202	-	303
309	-	412	159	51	206	-	309
314	-	419	160	52	210	-	314
320	-	426	161	53	213	-	320
325	-	434	162	54	217	-	325
331	-	441	163	55	220	-	331
336	-	448	164	56	224	-	336
341	-	455	165	57	228	-	341
347	-	463	166	58	231	-	347
352	-	470	167	59	235	-	352
358	-	477	168	60	239	-	358
363	-	484	169	61	242	-	363
369	-	491	170	61	246	-	369
374	-	499	171	62	249	-	374
379	-	506	172	63	253	-	379
385	-	513	173	64	257	-	385
390	-	520	174	65	260	-	390
396	-	528	175	66	264	-	396
401	-	535	176	67	267	-	401
407	-	542	177	68	271	-	407
412	-	549	178	69	275	-	412
418	-	557	179	70	278	-	418
423	-	564	180	70	282	-	423
428	-	571	181	71	286	-	428
434	-	578	182	72	289	-	434
439	-	586	183	73	293	-	439
445	-	593	184	74	296	-	445
450	-	600	185	75	300	-	450
456	-	607	186	76	304	-	456
461	-	615	187	77	307	-	461
466	-	622	188	78	311	-	466
472	-	629	189	79	315	-	472
477	-	636	190	80	318	-	477

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Predicted body weight and ventilator volume range chart **MALE**

Non Acute Lung Injury			Height	PBW	Acute Lung Injury / ARDS		
6 ml/Kg	-	8 ml/Kg	(cm)	(Kg)	4 ml/Kg	-	6 ml/Kg
233	-	310	140	39	155	-	233
238	-	317	141	40	159	-	238
243	-	325	142	41	162	-	243
249	-	332	143	41	166	-	249
254	-	339	144	42	170	-	254
260	-	346	145	43	173	-	260
265	-	354	146	44	177	-	265
271	-	361	147	45	180	-	271
276	-	368	148	46	184	-	276
282	-	375	149	47	188	-	282
287	-	383	150	48	191	-	287
292	-	390	151	49	195	-	292
298	-	397	152	50	199	-	298
303	-	404	153	51	202	-	303
309	-	412	154	51	206	-	309
314	-	419	155	52	209	-	314
320	-	426	156	53	213	-	320
325	-	433	157	54	217	-	325
330	-	441	158	55	220	-	330
336	-	448	159	56	224	-	336
341	-	455	160	57	228	-	341
347	-	462	161	58	231	-	347
352	-	470	162	59	235	-	352
358	-	477	163	60	238	-	358
363	-	484	164	61	242	-	363
368	-	491	165	61	246	-	368
374	-	499	166	62	249	-	374
379	-	506	167	63	253	-	379
385	-	513	168	64	257	-	385
390	-	520	169	65	260	-	390
396	-	527	170	66	264	-	396
401	-	535	171	67	267	-	401
406	-	542	172	68	271	-	406
412	-	549	173	69	275	-	412
417	-	556	174	70	278	-	417
423	-	564	175	70	282	-	423
428	-	571	176	71	285	-	428
434	-	578	177	72	289	-	434
439	-	585	178	73	293	-	439
445	-	593	179	74	296	-	445
450	-	600	180	75	300	-	450
455	-	607	181	76	304	-	455
461	-	614	182	77	307	-	461
466	-	622	183	78	311	-	466
472	-	629	184	79	314	-	472
477	-	636	185	80	318	-	477
483	-	643	186	80	322	-	483
488	-	651	187	81	325	-	488
493	-	658	188	82	329	-	493
499	-	665	189	83	333	-	499
504	-	672	190	84	336	-	504

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SUPPORTING DOCUMENT ONE – EQUALITY IMPACT ASSESSMENT TOOL		
To be completed by the Treatment pathway owner and submitted to the appropriate committee for consideration and approval.		
		Yes/No
1.	Does the treatment pathway affect one group less or more favourably than another on the basis of:	
	Race	**NO**
	Ethnic origins (including gypsies and travellers)	**NO**
	Nationality	**NO**
	Gender	**NO**
	Culture	**NO**
	Religion or belief	**NO**
	Sexual Orientation	**NO**
	Age	**NO**
2.	Is there any evidence that some groups are affected differently?	**NO**
3.	If you have identified potential discrimination, are any exceptions valid, legal and/or justifiable?	**NO**
4.	Is the impact of the policy/guidance likely to be negative? If so can the impact be avoided?	**NO**
5.	What alternatives are there to achieving the policy/guidance without the impact?	**NO**
6.	Can we reduce the impact by taking different action?	**NO**
7.	Other comments	

If you have identified a potential discriminatory impact of this key document, please refer it to Human Resources, together with any suggestions as to the action required to avoid/reduce this impact.

For advice in respect of answering the above questions, please contact Human Resources.

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SUPPORTING DOCUMENT TWO – FINANCIAL IMPACT ASSESSMENT		
To be completed by the Treatment pathway owner and submitted to the appropriate committee for consideration and approval.		
		Yes/No
1.	Does the implementation of this document require any additional Capital resources	**NO**
2.	Does the implementation of this document require additional revenue	**NO**
3.	Does the implementation of this document require additional manpower	**NO**
4.	Does the implementation of this document release any manpower costs through a change in practice	**NO**
5.	Are there additional staff training costs associated with implementing this document which cannot be delivered through current training programmes or allocated training times for staff	**NO**
6.	Other comments	

If the response to any of the above is yes, please complete a business case and which is signed by your Finance Manager and Directorate Manager for consideration by the Accountable Director before progressing to the relevant committee for approval

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