Kacmarek: Egan's Fundamentals of Respiratory Care, 10th Edition

Chapter 41: Respiratory Failure and the Need for Ventilatory Support

Answer Key for the Workbook

CHAPTER OBJECTIVES
1. Define acute respiratory failure. (Q: 1)
2. Differentiate between hypoxemic respiratory failure (type I) and hypercapnic respiratory failure. (type II). (Q: 3)
3. Discuss the causes of acute respiratory failure. (Q: 6)
4. Discuss the differences between chronic respiratory failure and acute-on-chronic respiratory failure. (Q: 8-10)
5. Identify the complications of respiratory failure. (Q: 11-12)
6. Discuss the indication for ventilatory support. (Q: 31)
7. Discuss general management principles of hypoxemic and hypercapnic respiratory failure. (Q: 4, 6)
8. Discuss indications for noninvasive ventilation. (Q: 23-30)

WORD WIZARD
Reference: Glossary
B. Another term for dynamic hyperinflation
F. Hyperinflation, elevated airway pressures, and procedures lead to this harmful outcome
G. Low rates, high flows, and moderate volumes avoid this harmful outcome
C. The oxygen is too low
D. The carbon dioxide is too high
A. Switching from abdominal to ribcage breathing
E. The physiologic cost of increased dead space and resistance

SO, WHAT COULD GO WRONG?
1. Reference: Page 990
   "...inability to maintain either the normal delivery of oxygen to the tissues or the normal removal of carbon dioxide from the tissues."

2. Reference: Page 990
   A. PaO₂ < 60 mm Hg (on room air at sea level)
   B. PaCO₂ >40 mm Hg (in otherwise healthy individuals on room air at sea level)

3. Reference: Page 990
   A. Type I is acute hypoxemic failure
   B. Type II is hypercapnic failure
LET'S REVIEW
4. Reference: Page 990
   A pH 7.45, PaCO₂ 33 mm Hg, PaO₂ 40 mm Hg represents acute respiratory alkalosis with hypoxemia. Remember that the most common cause of respiratory alkalosis is hypoxemia. Admittedly, 40 is pretty severe hypoxemia. You could also see this in a patient with a higher PO₂, especially if they were on oxygen.

TELL ME MORE, TELL ME MORE
5. Reference: Page 994
   PaCO₂ and alveolar ventilation vary inversely.

6. Reference: Page 996
   A. Decreased ventilatory drive
      1. Drug overdose/sedation
      2. Sleep apnea
   B. Respiratory muscle fatigue/failure
      1. Guillain-Barré
      2. Myasthenia gravis
   C. Increased work of breathing
      1. COPD
      2. Asthma

7. Reference: Page 996
   Hypermetabolic states, like severe burns

ACUTE-ON-CHRONIC RESPIRATORY FAILURE
8. Reference: Page 997
   Kidney retention of bicarb or renal compensation for the increased CO₂

9. Reference: Page 997
   These patients are not judged by the simple criteria of increased PaCO₂, but by a significant increase above baseline for that patient. We look at pH more than CO₂.

10. Reference: Page 997
    A. Bacterial or viral infections
    B. CHF
    C. Pulmonary embolus
    D. Chest wall dysfunction
    E. Medical noncompliance

11. Reference: Page 997
    A. Normalize pH (and avoiding mechanical ventilation if possible!)
    B. Elevating SaO₂ to ≥90%
    C. Improving airflow
    D. Treating infection
12. Reference: Page 997
   A. Invasive catheters
   B. Mechanical ventilation
   C. Endotracheal tubes, suctioning, handwashing

13. Reference: Page 997
   A. Arrhythmias, hypotension, heart failure
   B. Hemorrhage, dysmotility
   C. Acute renal failure, positive fluid balance leading to edema

14. Reference: Page 957
   A. Bacteremia and sepsis
   B. Malnutrition or nutrition that increases work of breathing
   C. Psychosis occurs in a high percentage of patients due to lack of sleep

TUBE 'EM
15. Reference: Page 998
   Support the patient until the underlying problem is resolved

16. Reference: Page 998
   A. 35 to 45; >55
   B. 7.35 to 7.45; <7.20
   C. 65 to 75; <10
   D. >-80; ≥ -20 mm Hg
   E. >120; <2 × VE
   F. 5 to 6; >10 L/min
   G. -.25 to 0.4; >0.60
   H. 25 to 65; >350
   I. 350 to 450; <200

17. Reference: Page 998
   P/F ratio of less than 200 is bad; >350 is normal.

18. Reference: Page 998
   Assessment of pH allows you to differentiate acute and chronic hypercapnia. It's really the
   most important criterion because it shows cardiopulmonary homeostasis (or lack of it).

ASSESSMENT OF FATIGUE
19. Reference: Page 999
   A. MIP is maximum inspiratory pressure generated in 20 seconds of breathing against a
      closed glottis.
   B. Normal is always >60 cm H2O. <30 is poor. <-10 is awful.

20. Reference: Page 998
   A. A reversible decrease in central respiratory drive
   B. Reversible impairment of in the transmission of neural impulses
   C. Reversible impairment of contractile response to neural impulses
21. Reference: Page 998  
Neuromuscular disease

22. Reference: Page 998  
A. COPD  
B. Kyphoscoliosis  
C. Obesity

**STRATEGIES**

23. Reference: Pages 1000-1001  
Noninvasive ventilation is the application of positive pressure without an artificial airway. There are many possible types of support in NPPV.

24. Reference: Pages 1000-1001  
A. Compensating for work caused by intrinsic PEEP (trapped air)  
B. Supplementing a low tidal volume  
C. Unloading respiratory muscle workload  
D. Recruiting alveoli (also reduces preload)

25. Reference: Pages 1000-1001  
A. It appears to be a first choice over intubation in treating acute respiratory failure in COPD exacerbations but is not as useful for severe stable COPD.  
B. Severe exacerbation  
C. It varies. About half of patients do tolerate it.

26. Reference: Page 1001  
CHF or left ventricular failure with pulmonary edema is treated with NIV. It is a first choice for eligible patients over intubation because (see No. 24) it reduces both preload and afterload for the overworked heart.

27. Reference: Page 1001  
It can work, but it is still controversial due to the lack of large clinical trials.

28. Reference: Page 1001  
There are some positive benefits, but overall too many fail (50%), and mortality for ALI/ARDS remains high. Basically, it takes longer to resolve.

29. Reference: Page 1001  
Only helps normalize carbon dioxide, but does not impact quality of life or disease progression.

30. Reference: Page 1001  
NIV is used for nocturnal ventilation for neuromuscular disorders. The ability to protect the upper airway is one criterion that has to be met. Quality of life and reduced pneumonia and hospitalization are benefits. NIV cannot stop the progression of the disease, however.
LUNG INVASION
31. Reference: Page 1002
   A. Tidal volume
   B. Frequency
   C. Flowrate

32. Reference: Page 1002
   A. Inspiratory time
   B. Inspiratory pressure
   C. Frequency

33. Reference: Page 1002
   A. PEEP
   B. FIO₂

34. Reference: Page 1002
   A. APRV
   B. Liquid
   C. IRV or HFOV

SPECIAL CASES
35. Reference: Page 1002
   Ventilation with small tidal volumes (6 ml/kg) increases survival.

36. Reference: Page 1002
   Alkalosis and hypocapnia reduce cerebral blood flow. This should be used cautiously and for brief periods of time.

37. Reference: Page 1002
   25 to 30 mm Hg

38. Reference: Page 1002
   PEEP may increase ICP.

39. Reference: Page 1003
   A. Barotrauma
   B. Auto-PEEP and increased work of breathing

40. Reference: Page 1003
   A. 8 to 10 ml/kg is the number in Chapter 44, but here they use 6 to 8. Try 8 for severe COPD.
   B. 70 to 100 L/min—you need short I times.

41. Reference: Page 1003
   Application of extrinsic PEEP. Splinting the airway at the auto-PEEP level seems to lessen the effect of the auto-PEEP.
42. Reference: Page 1003  
To normalize the pH but not the PaCO₂; avoid overoxygenation

**SUMMARY CHECKLIST**  
Reference: Page 1003  
43.  50; 60  
44. Hypoxemic; shunt; hypoventilation  
45. Hypercapnic; fatigue; breathing  
46. hypercapnia, polycythemia  
47. clinical  
48. work of breathing  
49. noninvasive  
50. minute

**CASE STUDIES**  
**Case 1**  
Reference: Page 991  
51. Acute respiratory alkalosis with hypoxemia (moderate)  
52. \[ \text{PAO}_2 = (760 - 47) \times 0.21 - (32 \div 0.8) = 150 - 40 = 110 \text{ (PAO}_2) \]  
\[ \text{P(A-a)O}_2 = 110 - 50 = 60 \text{ mm Hg} \]  
53. Type I or hypoxemic respiratory failure  
54. The textbook recommends administering 100% oxygen to help differentiate \( \dot{V}/\dot{Q} \) mismatch from shunting. You would probably start her on a cannula at 4 to 6 L depending on her clinical presentation.

**Case 2**  
Reference: Page 994  
55. Acute respiratory acidosis with hypoxemia (mild)  
56. \[ \text{PAO}_2 = (760-47) \times 0.21 - (60 \div 0.8) = 150-75 = 75 \text{ mm Hg} \]  
\[ \text{P(A-a)O}_2 = 75 - 65 = 10 \text{ mm Hg} \]  
57. Type II or hypercapnic respiratory failure  
58. Oxygen therapy is not the issue in this case. The patient is hypoventilating, and this is the cause of the hypoxemia. Intubation and mechanical ventilation are the most likely choices of treatment.
Case 3
Reference: Page 997
59. Partially compensated respiratory acidosis with hypoxemia (moderate)

60. \( \text{PAO}_2 = (76 - 47) \times 0.21 - (70 \div 0.8) = 150 - 88 = 62 \text{ mm Hg} \)
   \( \text{P(A-a)O}_2 = 62 - 50 = 12 \text{ mm Hg} \)

61. This patient also has hypercapnic respiratory failure, but it is acute respiratory failure superimposed on chronic respiratory failure.

62. The goal for this patient is to normalize the pH while avoiding mechanical ventilation. Bronchodilators would be a simple starting point. Consider bronchial hygiene techniques. He also needs a small amount of oxygen, with the goal to increase the \( \text{SaO}_2 \) to 90%. 2 L via cannula or 28% by AEM.

**WHAT DOES THE NBRC SAY?**
63. Reference: Page 990
   A. Provide intubation and mechanical ventilation.

64. Reference: Page 1002
   C. Administer oxygen therapy via CPAP.

65. Reference: Page 1003
   C. Increase the rate.

66. Reference: Page 1003
   D. Increase the PEEP.

67. Reference: Page 1003
   D. Change to synchronized intermittent mandatory ventilation (SIMV).

68. Reference: Page 1003
   B. 28% air entrainment mask

69. Reference: Page 1000
   A. respiratory failure secondary to shunting

**FOOD FOR THOUGHT**
69. Reference: Page 968
   Neuromuscular diseases would be an example of a condition best assessed by VC and MIP. Blood gases are especially useful in patients with COPD, or abnormalities of drive like obesity/hypoventilation.