Sleep Deprivation in Intensive Care Unit (ICU) patients: A Case study

Contents

Max

- 71 year old male

- Presented to GP
  - 6 month history of worsening SOB on exertion
  - progressive dyspnoea
  - Sp02 73% on RA
  - Dry cough

History

- 8 months prior- Recent Dx Idiopathic Pulmonary Fibrosis (IPF)
  - Pulmonary function test (PFT)- result consistent with a restricted pattern
  - High Resolution CT(HRCT)- course, diffuse, pulmonary interstitial fibrosis without any evidence of ground glass opacification

- Prior medical history
  - Hypertension
  - **Anxiety**
  - Prostatic hypertrophy
  - Smoker for 25 years, ex-smoker for 24 years

On examination

- Nil evidence of infection
- Unknown cause of deterioration

- Transferred to tertiary referral hospital. Admitted to ward
  - Day 2 = RRT- Sp02 deterioration ⬇ maximum Sp02 80% on 15L 02 via NRB
  - ⬆ WOB, RR, diaphoretic

- Admission into Intensive Care Unit

Treatment

- Clinical impression: Type 1 (hypoxemic) respiratory failure secondary to an acute exacerbation of IPF, sepsis and possible myocardial infarction

- Treatment
  - Non-invasive ventilation (NIV), more specifically, Bi-Level Positive Airway Pressure (BiPAP)
  - High-flow oxygen therapy for breaks/ not tolerating BiPAP

DAY 1

- BiPAP
  - Commenced on:
    - Inspiratory Positive Airway Pressure (IPAP)12cm H20
    - Expiratory Positive Airway Pressure (EPAP) 8 cm H20
    - Pressure Support (PS) 4 cm H20
  - Four hours after commencement:
    - IPAP increased to 18cm H20
    - EPAP increased to 12 cm H20
    - PS 6 cm H20
  - Fio2 titrated between .40 –.50 to achieve Sp02 >90%
  - ABG attended 8 hours post BiPAP commencement– significant improvement in Max's oxygen levels (Pa02 66.1 mmHg)

Day 1

- Sputum cultures revealed gram positive cocci
- Commenced on
  - Tazocin IV 4.5 g q6h
  - Azithromycin IV 500 mg for 2 days
- Commenced corticosteroids for tx. of pulmonary fibrosis
  - Methylprednisolone IV 1g per day/2 days
  - Changed to oral prednisone 50mg once daily
- Regular nebulisers to assist secretions
  - Saline and salbutamol 5mg q4h
- Regular anti-hypertensive medication continued
- Enoxaparin 40mg daily as deep-vein thrombus prophylaxis

DAY 2

- HRCT-used to display underlying fibrotic changes of IPF. Results revealed:
  - 'Diffuse ground glass changes and pre existing fibrosis in left base and alveolitis'
  - Diffuse changes; often produce a worse outcome

- Echocardiogram
  - Evidence of a recent apical myocardial infarction
  - Moderate mitrial and tricuspid regurgitation

- Transthoracic echocardiogram
  - Right ventricular hypertrophy and segmental dysfunction

- The UpToDate topic 'Treatment of Idiopathic Pulmonary fibrosis'(2013) states that both cardiovascular disease and pulmonary infection are common complications of IPF.

DAY 2

- Family meeting attended
  - ?Biopsy. Decided risks outweigh benefit
- No specific treatment available for the condition of IPF
- Therapy is aimed at
  - Keeping the patient comfortable
  - Supporting lung function for comfort measures
- BiPAP therapy with supplemental High Flow O2 continued

Pathophysiology of IPF

- Idiopathic pulmonary fibrosis
  - Type of interstitial lung disease (ILD)
  - Deep lung tissues become inflamed and irreversibly damaged
  - ILD- can occur without cause; called idiopathic ILD, IPF most common of this type
  - Chronic, relentlessly progressive fibrotic disorder of lover respiratory tract
  - Formation of scar tissue in the connective tissues of the lungs as sequel to possible inflammation or irritation

Pathophysiology of IPF

- Disease progression is insidious
- Predominantly affects older adults > 55 years of age
- The course of the disease may be unpredictable
  - Over period of months to years
  - Symptoms generally slowly progress
  - Acute deteriorations do occur, such as Max's case

- Symptoms can include:
  - Progressive dyspnoea
  - Shortness of breath (SOB)
  - Dry cough
  - Weakness and fatigue
  - Discomfort in the chest
  - Loss of appetite
  - Unexplained weight loss
  - Clubbing of the fingertips

Pathophysiology of ipf

- Lung tissue from patients with IPF shows a characteristic set of features known as usual interstitial pnemonia (UIP)
- The mechanism of progressive fibrosis in IPF remains difficult to understand, however it is thought ot be possible that:
  - Multiple micro injuries to alveolar epithelial cells induce a fibrotic environment
  - The growth factors secreted by these injured epithelial cells activate and recruit fibroblasts.
  - Following this fibroblast activation, proliferation and differentiation by epithelial injury, fibrobalst and myofibroblasts organise into fibrotic focci
  - Such appearance of fibrotic foci precedes the developent of end-stage fibrosis (Max's current stage)
  - The progression of this fibrosis is aided by a variety of growth factors, such as infection
  - Leading to relentless physiologic deterioration

Pathophysiology of ipf

- Such restrictive physiology causes
  - Decreased measures of forced vital capacity (FVC)
  - Decreased measures of forced expiratory volume in one second (FEV1)
  - Reduction of total lung capacity (TLC)
  - Due to fibrotic foci, surface area for gas exchange has diminished significantly → difficulty breathing

- Max's physiology
  - Diagnostic PFT- FVC mildly reduced and FEV1 at the lower limit of normal
  - Diffusion capacity is moderately reduced and consistent with IPF demonstrating impairment in gas exchange

Prognosis

- IPF is recognised to have poor prognosis
- Median survival period ranging from 2 to 4 years, particularly in acute exacerbations of IPF

- Lung transplantation is an option
  - Restricted to those who have relatively few co-morbidties

- At present:
  - No means for accurately predicting the clinical course
  - Nor a definitive consensus for treatment or cure for IPF
  - It is ultimately fatal

DAY 2

- Family meeting attended
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- No specific treatment available for the condition of IPF
- Therapy is aimed at
  - Keeping the patient comfortable
  - Supporting lung function for comfort measures

Day 3

- Max received <3hrs sleep previous two nights
- Sleep deprivation begins
  - Anxiety is a contributing factor; high reliance on BiPAP for relief of SOB symptoms
  - Discomfort associated with BiPAP use; claustrophobia, need for tight fitting mask, head straps
  - Very lethargic
  - Tired during the day, awake at night

- Quetiapine 12.5 mg commenced BD to assist with sleep deprivation secondary to pre-existing anxiety
  - SOOB during day
  - Majority of cares provided in day, except early morning wash in bed
  - Room quietened at night by pulling room door closed

Day 4

- Level of tiredness increasing
- Nil reserve; any exertion leaves Max very exhausted
- Pt beginning to loose positive outlook towards progression of illness
- Decided for a

- Reluctance from medical team to prescribe or initiate medications to assist with sleeping such as diazepam

Continuing days >10

- Sleep deprivation continued
- Nights with >4hrs sleep were valued, not common
- Max became weak, lethargic
- Intolerant to any major exertion (t/f to SOOB very exhausting)
- Did not feel he was improving
- Constantly struggling for breath
- Family aware of deteriorating condition
- Care focused on comfort measures while supporting lung function

Palliation

- Sadly, Max had become so reliant on NIV he was uncomfortable, unhappy, unable to enjoy activities such as eating, talking with family
- He decided he had done all possible, and with medical teams consult, palliation commenced
- Use of morphine and midazolam
- Private environment
- Family present
- Passed away within a day

Sleep in the Intensive Care Unit

- Patients experience severe alterations of sleep with
  - sleep loss
  - sleep fragmentation
  - sleep wake cycle disorganization.
- A multitude of research articles including Beecroft et al (2008) report than an ICU inpatients
  - "sleep was severely disrupted, reflected by decreased total sleep time and sleep efficiency, high frequency of arousals and awakenings and abnormal sleep architecture"
- Many factors may contribute to these abnormalities including
  - Intrinsic/ patient related factors (e.g., disease severity)
  - Extrinsic/ environmental factors (e.g., continuous exposure to light and noise, around-the-clock care, and

Sleep…

- Sleep deprivation is common amongst patients in intensive care units (ICU) and can lead to
  - physiological and psychological dysfunctions that affect the healing process
  - increase morbidity and mortality.
- The impact of sleep disturbances on morbidity and mortality in ICU patients remains unknown but inferences from experimental studies or indirect evidence suggest possible immune function alterations and neuropsychological dysfunction that could hamper weaning from assisted ventilation.

(Ellassen & Hopstock, 2011).

Sleep Architecture

- Structure of sleep
- Cyclical
- Periodic progression through defined states of recordings from:
  - electroencephalogram (EEG)
  - electrooculography (EOG)
  - electromyography (EMG)
- The output from these three sources is recorded simultaneously on a graph by a monitor as a hypnogram

Sleep Architecture

- Certain frequencies are characteristic, determine what stage of sleep/wake the subject is in, termed as:
  - Rapid eye movement (REM)
    - Eyes move rapidly from side to side
    - Most dreams occur
    - Muscles completely relaxed
  - Several non-REM stages
    - N1- EEG waves shift from fast alpha waves to slower theta waves, sudden muscle contractions
    - N2- EEG pattern of sleep spindles and K-complexes
    - N3- Slow wave sleep (SWS). Longer and slower delta waves (20- 50% brain activity)
    - N4- SWS. (>50% brain activity)

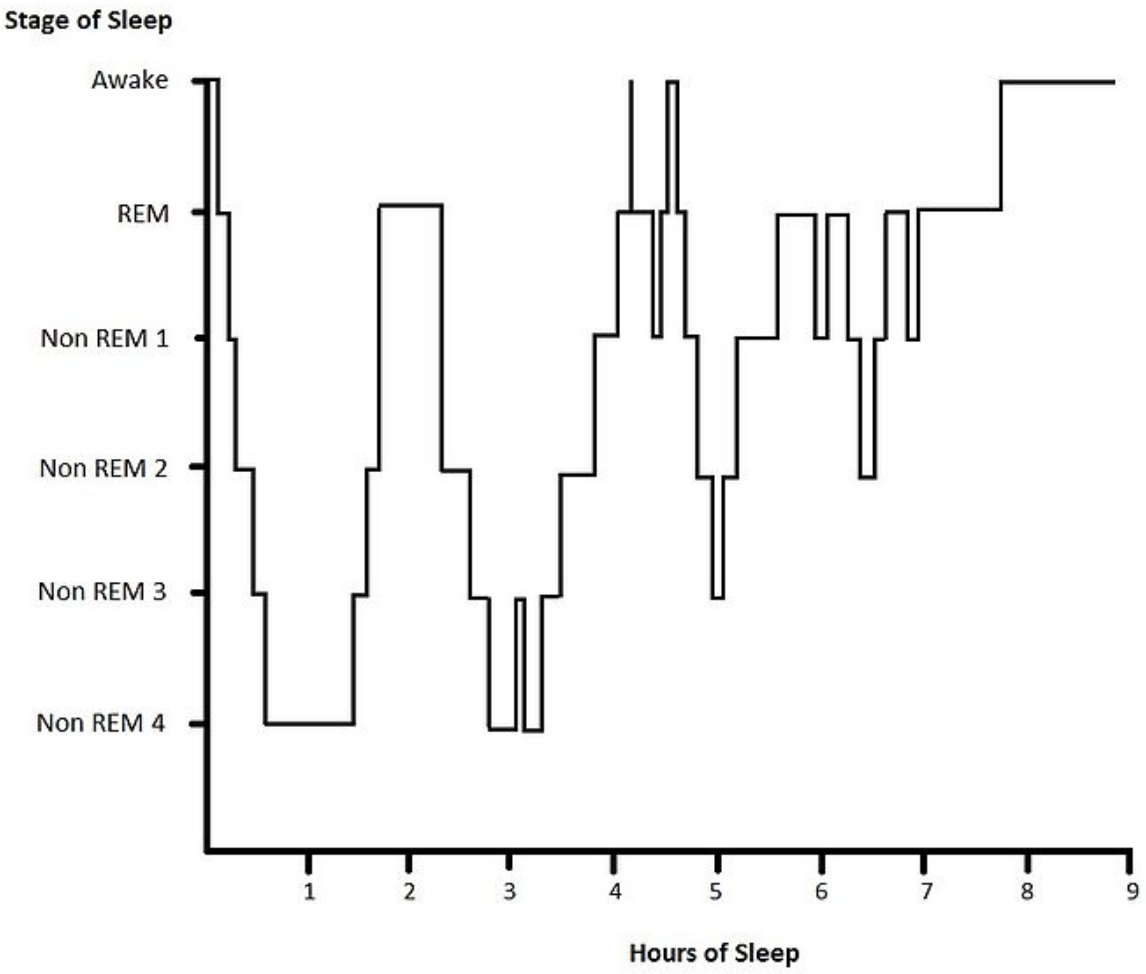
Sleep stages- Hypnogram

- Rapid stepwise progression
- 4-6 sleep cycles per major period of sleep
- Each around 90 min
- Deficits through each stage lead to sleep disorders

- Most SWS occurs in first one or two cycles (deeper sleep)

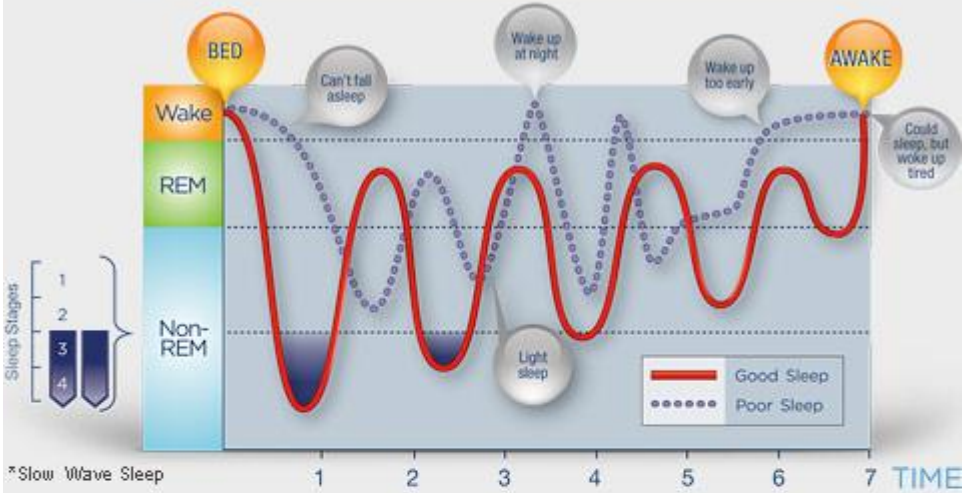
- Second half of sleeping period- most REM sleep + little or no SWS + brief periods of wakefulness which can be recorded but not usually perceived
- Stage 5 (REM) increases in frequency and length later during the sleep period before waking
- REM generally makes 20-25% sleep period for adults

Hypnogram


Stage of Sleep
Awake
REM
Non REM 1
Non REM 2
Non REM 3
Non REM 4
1
2
3
4
5
6
7
8
9
Hours of Sleep

SLEEP STAGE TRANSITION

The diagram below illustrates the difference between good sleep (red line) and poor sleep (dotted line) architecture.



The red line illustrates a deep and restful sleep pattern. The dotted line shows a more shallow and erratic sleep pattern.

SLEEP STAGES AND THE ROLE THEY HAVE ON SLEEP[3]

Sleep Stage	% of night	(Examples) Role of each stage
REM	25%	1 - Provides energy to brain and body 2 - Supports daytime performance 3 - Brain is active and dreams occur
Stage 1	75%	1 - Between being awake and falling aspleep 2 - Light sleep
Stage 2		1 - Onset of sleep 2 - Becoming disengaged from surroundings
Stage 3		1 - Deepest and most restorative sleep 2 - Muscles are relaxed, blood pressure drops and breathing becomes slower
Stage 4		3 - Energy is restored and hormones are released such as growth hormone, essential for growth and developement
Non-REM		

References:

3. National Sleep Foundation website: www.sleepfoundation.org/what-happens-when-you-sleep

How do we study sleep in Icu?

- Polysonography (PSG)
  - Most accurate & effective assessment of sleep
  - Supported by reports from ICU patients on their inability to sleep well in ICU
  - Multiple limitations for use:
    - Cost
    - Impracticality
    - High number of electrical machines in ICU environment can interfere with recording
    - Discomfort associated with use
  - Limited number of studies conducted using PSG

- Self report
  - Effective means of gaining data around experiences with sleep as inpatient
  - subjective

- Actigraphy
  - Unreliable measurement tool, overestimates quantity of sleep

- Patient assessment conducted by bedside nurse
  - Inaccurate and unreliable source of assessment
  - Nurses tend to overestimate the quantity of sleep

Sleep assessment

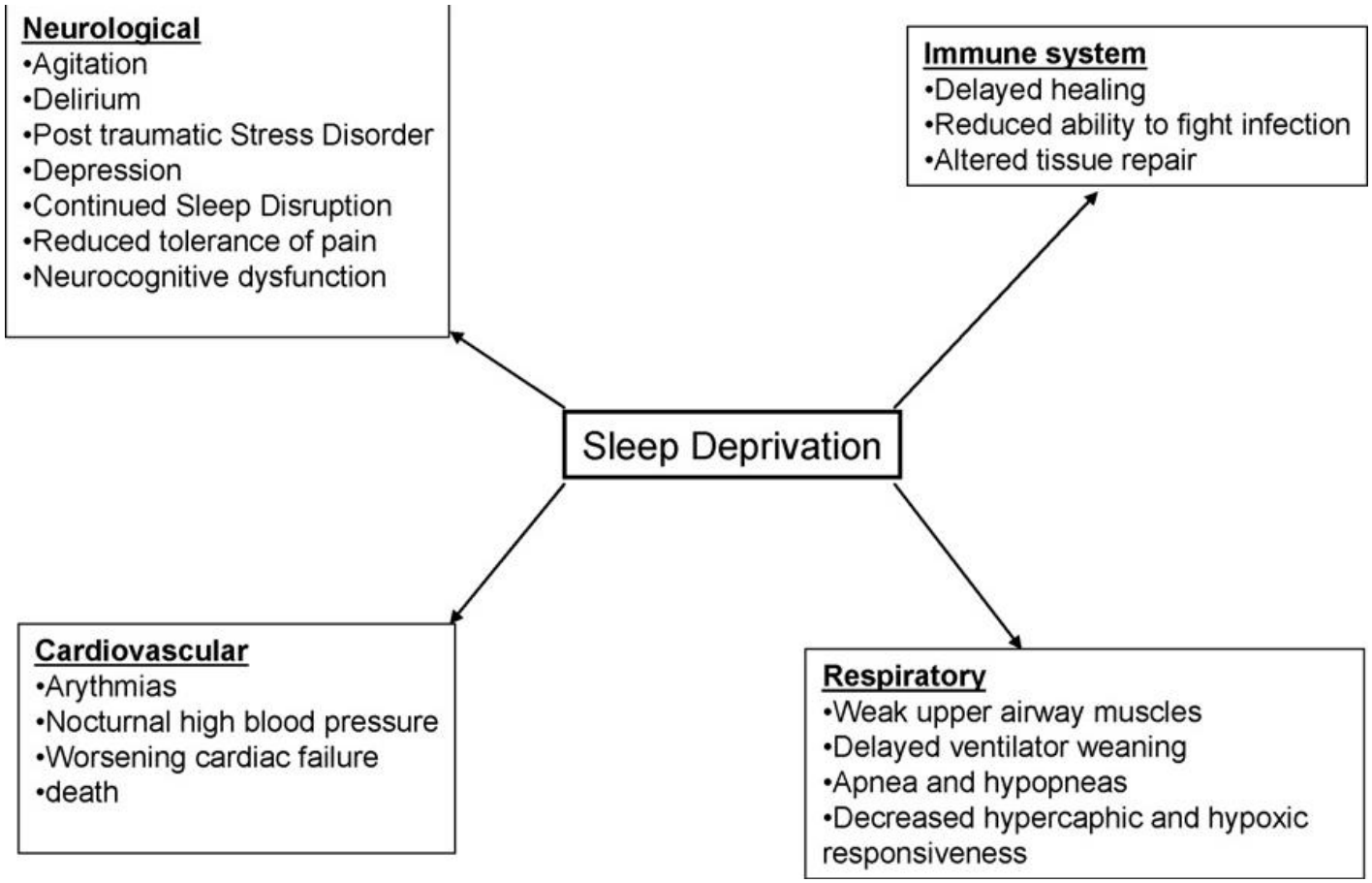
- Sleep can be assessed in terms of
  - Quantity; total sleep time and time spent in each sleep stage
  - Quality; fragmentation, sleep stage changes, wake after sleep onset, EEG sleep patterns
  - Distribution; relates to the 24 hour cycle

Sleep benefits

- Research has shown that sleep provides several benefits. **REM sleep** is said to be involved in the restoration of:
- Attention
- Learning
- Memory
- Emotional balance and mood mechanisms.

- **Deep, slow-wave sleep (N3 & N4)** appears to allow reconstruction, or maintenance, of physical integrity through nocturnal increases in protein synthesis and cell division

The multisystem impact of sleep deprivation on critically ill patients



(6)

Causes of sleep deprivation

- Intrinsic factors
- Noise
- Nursing interventions
- Light
- Pain
- Discomfort
- Modes of ventilation
- Medications

- All have been regularly cited as causes of sleep deprivation in critically ill patients (Friese, 2008; Parthasarathy and Tobin, 2004 ; Jacobi et al., 2002; Honkus, 2003)

Factors that contribute to sleep disturbance in ICU patients

- INTRINISIC FACTORS
  - Severity of illness
  - When compared to healthy individuals sleeping in ICU, such patients exhibited
    - Higher hourly awakening rates
    - Shorter sleep times (quantity)
    - Reduced SWS (N3 & N4)
  - However this may be affected not only by severity of illness but other factors such as pain, discomfort and anxiety
  - Significantly greater numbers of arousals and awakenings per hour were found in patients with higher severity scores and in patients who died (Parthasarathy, 2003)

Factors that contribute to sleep disturbance in ICU patients

- ENVIRONMENTAL FACTORS- NOISE
  - ICU environment- not conductive to restorative sleep
  - High level of noise
  - Frequent and loud alarms
  - Need for 24 hr patient care

Factors that contribute to sleep disturbance in ICU patients

- LIGHT EXPOSURE
  - Continuous light exposure
  - Disappearance of the natural day-night rhythm
  - Alters the circadian clock
  - Nocturnal light intensities vary across ICU's but can exceed 1000lx
  - Such a level can impact melatonin secretion
  - One study reported light exposure induced less sleep disruption than noise or patient-care activities

Factors that contribute to sleep disturbance in ICU patients

- NURSING INTERACTIONS/ PROCEDURES
  - A study involving completion of questionnaire by patients recently discharged from ICU
  - Patients reported that vital sign assessments ad phlebotomy were more disruptive than noise (Drouot et al 2008)

Factors that contribute to sleep disturbance in ICU patients

- MECHANICAL VENTILATION
  - Associated with abnormal sleeping patterns
  - Characterised by numerous arousals, similar to pattern in sleep apnoea patients
  - Recent evidence suggests the particular ventilator mode and settings, as well as patient-ventilator interactions may influence the degree of fragmentation and quality of sleep
  - PS- Higher PS at night associated hyperventilation, decreased PaC02 triggering central apnoea, in turn induces arousal or awakening causing sleep fragmentation
  - Assist-control ventilation (ACV)- similar effect of deleterous passive hyperventilation overnight

Factors that contribute to sleep disturbance in ICU patients

- MEDICATIONS
  - The effects of sedation or analgesia have not been systematically investigated in the ICU
  - Under suspicion as causes of sleep disturbances

- Sedatives
  - EEG activity similar between sedation and sleep
  - Propofol use leads to slow wave activity that mimics slow wave sleep
  - One study suggested that propofol may subserve a function that overlaps with sleep
  - However may have negative effects on sleep via modifications of circadian rhythm

- Drug discontinuation may elicit withdrawal reactions
  - Study revealed 30% of patients experienced insomnia after discontinuation of sedatives

Medications

- UpToDate reports:
- Use of **benzodiazepines** and **benzodiazepine receptor agonists** are associated with:
  - Improved ease of falling asleep
  - Reduced awakenings
  - Increased sleep time
  - Less daytime sleepiness
  - Better concentration
  - Better daytime performance
  - Considered a *therapeutic medication-induced change*

- However, discontinuation can be associated with rebound insomnia(ie, difficulty initiating or maintaining sleep which is worse than that experienced prior to the use of medication), particularly if high doses are used.

- Dosage is important; can cause different effects to sleep stages

Medications

- UpToDate reports:
- Use of **melatonin** and **melatonin receptor agonists**
  - Generally prescribed for the treatment of sleep onset insomnia
  - Ramelteon, a melatonin receptor agonist, reduces the amount of stage N1 sleep (light sleep)
    Considered a therapeutic effect
  - Melatonin also appears to reduce latency to sleep onset, however its effects of sleep architecture are inconsistent.

- Hence, patients do not generally experience longer sleep time or improved daytime function, but the ease of falling asleep improves

Medications

- UpToDate reports:
- Use of **atypical antipsychotic medications**
  - Often used as hypnotics
  - Studies in healthy patients with mood disorders and schizophrenia have found that **quetiapine**, ziprasidone, olanzapine and clozapine reduce both sleep latency and wake time after sleep onset, *thus increasing sleep time*
  - generally suppress REM sleep, while increasing amounts of stage N3

- However, due to long half-lives, daytime sedations occurs in 29-52% of patients receiving atypical antipsychotic medications, seen as a negative effect. Appropriate timing of doses

MEDICATIONS

- UpToDate reports:
- Any medication that passes through the blood-brain barrier has the potential to alter the quality or structure of sleep
- Other medications which can alter quality of sleep:
  - Other **central nervous system medications** have a variety of effects on sleep, both therapeutic and benign
    - Analgesics- Varying effects with multiple adverse effects on healthy individuals, however may improve sleep if pain is causing sleep disturbance
  - **Cardiac medications** including lipophilic beta adrenergic blockers and centrally acting adrenergic blockers
    - lipophilic beta adrenergic blockers (ie, metoprolol)- associated with daytime sleepiness, insomnia, hallucinations and nightmares
    - centrally acting adrenergic blockers (ie, clonidine)- associated with daytime sleepiness
  - **Pulmonary medications** including theophylline and systemic corticosteroids
    - Theophylline- associated with improved sleep and improved daytime alertness
    - Corticosteroids- associated with suppression of REM sleep and increased awakening after sleep onset

      (Note: inhaled corticosteroids do not appear to have the same adverse effects on sleep in most patients

Sleep promotion Strategies

- Specific measures are recommended to protect sleep and circadian rhythm in ICU
  - Minimising light, noise and nursing interventions
    - However, recent data showed that minimising such failed to dramatically improve sleep
  - Use of isolated rooms where possible
  - Clustering nursing cares to avoid unnecessarily disturbing patient sleep
  - One study support the use of earplugs- significantly increased quantity and shortened latency of REM sleep
  - By reducing nonspecific agitation, directly treating delirium may improve patient sleep

Sleep promotion Strategies

- VENTILATION
  - Ventilator settings must be selected carefully in order to avoid hyperventilation during sleep
  - Over assistance can promote central apnoea's and ineffective efforts, events which have been associated to trigger arousals, further disturbing the sleep quality and quantity

SLEEP promotion strategies

- MEDICATIONS
  - Subjective perceptions to sleep were improved by night-time Propofol or midazolam infusion
  - Melatonin given at 10pm improved sleep quantity without inducing psychomotor disturbances on the next day in one study, however not strongly supported by the evidence

- OVERALL, interventions to promote sleep
  - pain control (with analgesics and non-pharmacological interventions)
  - modification of the environment (sound level and lighting reduction)
  - promoting comfort
  - promoting psychological welfare (explaining procedures, apply relaxation techniques as music therapy)
  - establishing sleep and rest patterns.

This is ICU, should sleep be a priority?

- Sleep is important for healing and survival of critical illness

  (Richardson et al., 2007; Straham and Brown, 2004).
- Sleep deprivation impinges on
  - Recovery
  - ability to resist infection
  - brings about neurological problems such as delirium
  - respiratory problems because it weakens upper air way muscles thus prolonging the duration of ventilation, ICU stay and complicating periods just after extubation (Friese, 2008; Parthasarathy and Tobin, 2004)

As nurses…

- In one study based on nurses perception towards sleep promotion
  - the ICU nurses reported an overall interest and awareness in sleep-promoting interventions utilising all four approaches, but felt that the challenge of caring for critically ill patients with demands of frequent assessment and nursing may influence which interventions are prioritised.

Further research

- Because of the importance of good sleep in critically ill patients, further research is absolutely necessary.
- Based of literature review, the following types of studies are needed:
  - 1. Large multi-centre studies with investigation of sleep disturbances in larger and more homogeneous patient groups.
  - 2. Investigation of possible practical interventions for promoting sleep in the ICU, possible changes in ICU culture, and thus improvement of ICU environment;
  - More physiological variants of mechanical ventilation improving patient-ventilator synchrony;
  - Use of exogenous melatonin
  - More restrictive attitude towards many 'ICU drugs' known to cause sleep disturbances;
  - Rational for limited sedation.

- Interventions such as those suggested may improve sleep quality and stabilise circadian rhythm in critically ill patients.

Conclusion

- While some of these causes of sleep disruption can not be easily alleviated, every effort must be made to promote REM and SWS sleep.
- More research is needed to find solutions to sleep disruption in ICU.
- More research is needed to ascertain the impact of mechanical ventilation on sleep disruption
- Furthermore, more specific way of sleep assessment in the critically ill.
- Nurses need to minimise disruptions by clustering their care at night in order to allow patients to have the much needed REM sleep.

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