**Supplemental Table 43. Pre-morbid risk factors affecting sleep in ICU patients.**

|  |  |  |
| --- | --- | --- |
|  | **Associated with sleep disruption** | **No association with sleep disruption** |
| **Risk Factor** | **Objective sleep measures** | **Subjective sleep measures** | **Objective sleep measures** | **Subjective sleep measures** |
| **Sex** |  | \* Bihari N 100 (multivariate analysis) (under age 60, female sleep worse than males, over age 60, females rate sleep better than males) [1] | \* Trompeo N 29 [2] | \* Higgins N 20 [3]\* Nicolas N 104 [4] \* Freedman N 203 [5] |
| **Older age** |  | \* Higgins, N 20 [3]\*Bihari N 100 -age and sex [1]interaction (multivariate analysis)\* Engelmann N 66 [6] | \* Trompeo (427), N 29 [2]\* Roche Campo (2464), N 27 (abnormal wakefulness or abnormal sleep; abnormal EEG) [7]\* Chen N 85 [8] | \* Nicolas N 104 (< or >50 yrs) [4]\* Frisk N 31 (< or >75 yrs)) [9]\* Hardin N 18 [10]\* Freedman N 203 [5]\* Chen N 85 [8] |
| **Hx of HTN** |  |  | \* Trompeo N 29 [2] |  |
| **Hx of diabetes** |  |  | \* Trompeo N 29 [2] |  |
| **Dx of cancer** |  |  | \* Trompeo N 29 [2] |  |
| **Tx for hypo/hyper-****thyroidism** |  |  |  | Bihari N 100 (p=0.10) \*authors report this as significant [1] |
| **Reported poor quality of sleep at home** |  | \* Kamdar N 300 [11]\* Bihari N 100 [1]\* McKinley (41981) N 222 [12] |  |  |
| **Regular use of sleep medication at home vs. no use** |  | \* Kamdar N 300 [11]\* Bihari N 100 (p=0.07) [1] |  |  |

Trompeo (427) compared ICU patients with REM reduction vs. severe REM reduction.

**Supplemental Table 43. ICU and disease-related risk factors affecting sleep in ICU patients.**

|  |  |  |
| --- | --- | --- |
|  | **Associated with sleep disruption** | **No association with sleep disruption** |
| **Risk Factor** | **Objective sleep measures** | **Subjective sleep measures** | **Objective sleep measures** | **Subjective sleep measures** |
| **Days in ICU or LOS** |  |  |  | \* Frisk N 31 [9]\* Freedman N 203 [5]\* Simpson N 84 [13] |
| **Disease severity (APACHE II Score)**  | \* Fanfulla N 22 [14] |  | \* Roche Campo N 27 [7] | \* Little N 116[15]\* Hardin N 18 [10] |
| **SOFA Score** |  |  | \* Roche Campo (2464) N 27 [7] |  |
| **In surgical patients, type of surgery** |  |  |  | \* Nicolas N 104 [4]\* Simpson N 84 [13] |
| **Delirium** | \* Trompeo N 29 [2]\* Roche Campo N 27 [7] |  |  |  |
| **Disorientation to time of day** |  | \* Little N 116 (reported by 29%) [15]\* Ehlers N 34 (reported by 82.4 - 85.3%) [16] |  |  |
| **Immobility/ inability to lie comfortably post-op** |  | \* Ugras (3046) N 66 (reported by 63.6%) [17]\* Simpson N 84 (mentioned by 70.2%, score 2.5/4) [13] |  |  |
| **Temperature** |  |  |  | \* Hardin N 18 [10] |
| **Pain** |  | \* Little N 116 (reported by 40%) [15]\* Nicolas N 104 (reported by 20.2%) [4]\* Zhang N 152 (reported by 63.2%) [18]\* Jones N 100 (reported by 13%) [19]\* Ehlers N 34 (reported by 58.8 - 91.2%) [16]\* Ugras N 66 (reported by 59.1%) [17]\* Hofhuis N 24 (reported by 21%) [20]\* Simpson N 84 (score 2.6/ 4) [13] |  |  |
| **Fear, anxiety, or stress** |  | \* Jones (32004) N 100 (reported by 9%) [19]\* Nicolas (2904), N 104 (reported by 9.6%) [4]\* Ehlers (32006) N 34 (reported by 70.6 - 91.2%) [16]\* Ugras (3046) N 66 (reported by 27.3 - 56.1%) [17]\* Hofhuis (2846) N 24 (reported by 25%) [20]\* Simpson (8465), N 84 (score 2.1/ 4) [13] |  |  |
| **Headache** |  | \* Ugras (3046) N 66 (reported by 54.5%) [17] |  |  |
| **Dyspnea** |  | \* Zhang (20647) N 152 (reported by 38.8%) [18] |  |  |
| **Cough** |  | \* Zhang (20647) N 152 (reported by 57.9%) [18]\* Ehlers (32006) N 34 (reported by 44.1%) [16] |  |  |
| **N/V** |  | \* Ugras (3046) N 66 (reported by 36.4%) [17] |  |  |
| **Hunger** |  | \* Ugras (3046) N 66 (reported by 34.8%) [17] |  |  |
| **Thirst** |  | \* Ehlers (32006), N 34 (79.4%) [16] |  |  |
| **Needing to use toilet** |  | \* Ugras (3046) N 66 (reported by 30.3%) [17] |  |  |
| **Being naked** |  | \* Ugras N 66 (reported by 45.5%) [17] |  |  |
| **Gas exchange** | \* Fanfulla (2032) N 22 [14] |  | \* Roche Campo N 27 [7] |  |
| **Being together with/ seen by other patients** |  | \* Ugras N 66 (reported by 34.8 - 48.5%) [17] |  |  |
| **Feelings and worries related to family & loved ones** |  | \* Zhang N 152 (reported by 55.9%) [18]\* Ehlers N 34 (reported by 58.8%) [16]\* Ugras N 66 (reported by 54.4%) [17] |  |  |
| **Feeling lonely** |  | \* Ugras N 66 (reported by 40.9%) [17] |  |  |
| **Discomfort** |  | \* Little N 116 (reported by 35%) [15]\* Jones N 100 (reported by 45%) [19]\* Nicolas N 104 (reported by 11.6%) [4]\* Ugras N 66 (reported by 22.7%) [17] |  |  |
| **Feeling hot at night** |  | \* Ehlers N 34 (reported by 32.4%) [16] |  |  |
| **Feeling cold at night** |  | \* Ehlers N 34 (11.8%) [16] |  |  |
| **Inability to perform usual routine before sleep** |  | \* Simpson N 84 (reported by 57.1%, score 2.1/ 4) [13] |  |  |
| **“Environment” or “space”** |  | \* Jones N 100 (reported by 21%) [19]\* Ehlers N 34 (50.0%) [16] |  |  |
| **Unfamiliar/ strange environment** |  | \* Zhang N 152 (reported by 42.1%) [18]\* Ehlers N 34 (reported by 47.1%) [16]\* Ugras N 66 (reported by 51.5%) [17] |  |  |
| **Unfamiliar nurses** |  | \* Ehlers N 34 (55.9%) [16] |  |  |
| **“Equipment ”** |  | \* Simpson N 84 (score 2/4) [13] |  |  |
| **“Bed”** |  | \* Simpson N 84 (score 2.3/4) [13] |  |  |
| **Nursing care & interventions** |  | \* Jones N 100 (reported by 14%) [19]\* Zhang N 152 (reported by 36.2%) [18]\* Elliott N 47 [21]\* Elliott N 45 [22]\* Freedman N 203 [5]\* Simpson N 84 (score 2.1/ 4) [13] |  | \* Nicolas N 104 [4]But in Nicolas study, reported to have been a factor by N 11/ 104 (objective measure of # of interventions did not show this effect) |
| **Vital signs** |  | \* Freedman N 203 [5] |  |  |
| **Phlebotomy** |  | \* Freedman N 203 [5] |  |  |
| **Medication administration** |  | \* Freedman N 203 [5] |  |  |
| **Diagnostic tests/ Procedures** |  | \* Elliot N 47 [21]\* Ugras N 66 (reported by 27.3%) [17]\* Elliott N 45 [22]\* Freedman N 203 [5]\* Simpson N 84 (score 2.3/ 4) [13] |  |  |
| **Worries about unpredictable check/ being constantly observed** |  | \* Zhang N 152 (reported by 48%) [18]\* Ugras N 66 (reported by 31.8%) [17] |  |  |
| **Noise** | \* Freedman N 22 (accounted for 17% of arousals) [23]\* Fanfulla N 22 (accounted for 10% of nighttime arousals) [14] | \* Little N 116 (reported by 42%) [15]\* Nicolas N 104 (reported by 10.6%) [4]\* Zhang N 152 (variably reported by 13.2 - 34.2%) [18]\* Jones N 100 (reported by 51%) [19]\* Elliot N 47 [21]\* Ehlers N 34 (reported by 91.2%) [16] \* Hofhuis N 24 (reported by 54%) [20]\* Elliott N 45 [22]\* Freedman N 203 [5] | \* Elliot N 53 [21]\* Elliott N 45 [22] | \* Frisk N 31 [9]\* Yinnon N 12 (33%) [24]\* Hu N 45[25] |
| **Telemetry alarms** |  | \* Freedman N 203 [5] |  |  |
| **IV pump alarms** |  | \* Freedman N 203 [5]\* Bihari N 100 [1] |  |  |
| **Pulse oximeter** |  | \* Freedman N 203 [5] |  |  |
| **Others talking** |  | \* Little N 116 (reported by 33%) [15]\* Zhang N 152 (variably reported by 15.8-40.8%)[18]\* Ehlers N 34 (reported by 35.3 - 58.8%) [16]\* Freedman (542), N 203 [5] |  |  |
| **Lights** |  | \* Little N 116 (reported by 40%) [15]\* Jones N 100 (reported by 16%) [19]\* Elliot N 47 [21]\* Ehlers N 34 (reported by 64.7%) [16]\* Elliott N 45 [22]\* Freedman N 203 [5]  | \* Fanfulla N 22 [14]\* Elliott N 45 [22] | \* Yinnon N 12 (34%) [24] |
| **IV catheters, tubes** |  | \* Little N 116 (reported by 33%) [15]\* Ehlers N 34 (reported by 61.8 - 88.2%) [16]\* Ugras N 66 (reported by 56.1%) [17] |  |  |
| **Television** |  | \* Bihari N 100 [1]\* Freedman N 203 [5] |  |  |
| **Phone** |  | \* Bihari N 100 [1]\* Freedman (542) N 203 |  |  |
| **Beepers** |  | \* Freedman (542) N 203 [5] |  |  |
| **Lack of privacy** |  | \* Ehlers N 34 (64.7%) [16] |  |  |
| **Hospital attire** |  | \* Ehlers N 34 (52.9%) [16] |  |  |
| **Dislike using urinals and/ or bedpans** |  | \* Ehlers N 34 (32.4%) [16] |  |  |
| **Blood pressure cuff smelling badly** |  | \* Ehlers (32006), N 34 (88.2%) [16] |  |  |
| **“IV sedation”** |  |  |  | \* Little (1733) N 116 |
| **Use of “sleeping pills”** |  |  |  | \* Little (1733) N 116 |
| **Use of “hypnotic” vs. none** |  |  |  | \* Frisk (6028), N 31 |
| **Benzo dose or bezo vs. no benzo** | \* Trompeo N 29 [2] |  | \* Fanfulla N 22 [14]\* Elliott N 45 [22] | \* Elliott N 45 [22] |
| **Propofol dose & propofol vs. placebo** | \* Kondili N 12 [26] |  | \* Trompeo N 29 [2] |  |
| **Morphine dose** |  |  | \* Trompeo N 29 |  |
| **Midaz vs. propofol** |  |  |  | \* Treggiari-Venzi N 40 [27] |
| **Steroids vs. no steroids** |  | \* Bihari (1595) N 100 |  |  |
| **Foreign body sensation due to intubation** |  | \* Zhang (20647) N 152 (reported by 53.9%) |  |  |
| **Spontaneous breathing vs. mechanical ventilation (any mode)** | \* Roche Campo (31981) N 16\* Elliot (31948) N 53\* Elliott (43720) N 45 |  | \* Fanfulla N 22 [14] | \* Little N 116 [15]\* Elliott N 45 [22]\* Freedman N 203 [5] |
| **Spontaneous mode (vs. controlled modes)** | \* Parthasarathy N 11 [28]\* Andrejak N 26 [29]  |  | \* Toublanc N 20 [30] |  |
| **PAV+ vs. PS** | \* Alexopoulou N 17 [31]\* Bosma N 13 [32] |  |  |  |
| **Clinically adjusted PSV vs. automatically adjusted PSV** | \* Cabello N 15 [33] |  |  |  |
| **NIV duration** |  |  | \* Roche Campo N 27 [7] |  |
| **Spontaneous breathing vs. NIV** | \* Drouot N 24 [34] |  |  |  |
| **Patient-ventilator asynchrony on NIV** | Cordoba-Izquierdo N 24 [35] |  |  |  |
| **Sound related to NIV** | Cordoba-Izquierd N 24 [35] |  |  |  |
| **“Ventilation system”** |  | \* Simpson N 84 (score 2.2/ 4) [13] |  |  |

Trompeo [2] compared ICU patients with REM reduction vs. severe REM reduction.

Cabello [33] showed difference only in Stage 2 sleep.

**References**

1. Bihari S, Doug McEvoy R, Matheson E, Kim S, Woodman RJ, Bersten AD: **Factors affecting sleep quality of patients in intensive care unit**. *J Clin Sleep Med* 2012, **8**(3):301-307.

2. Trompeo AC, Vidi Y, Locane MD, Braghiroli A, Mascia L, Bosma K, Ranieri VM: **Sleep disturbances in the critically ill patients: role of delirium and sedative agents**. *Minerva Anestesiol* 2011, **77**(6):604-612.

3. Higgins PA: **Patient perception of fatigue while undergoing long-term mechanical ventilation: incidence and associated factors**. *Heart Lung* 1998, **27**(3):177-183.

4. Nicolás A, Aizpitarte E, Iruarrizaga A, Vázquez M, Margall A, Asiain C: **Perception of night-time sleep by surgical patients in an intensive care unit**. *Nurs Crit Care* 2008, **13**(1):25-33.

5. Freedman NS, Kotzer N, Schwab RJ: **Patient perception of sleep quality and etiology of sleep disruption in the intensive care unit**. *Am J Respir Crit Care Med* 1999, **159**(4 Pt 1):1155-1162.

6. Engelmann C, Wallenborn J, Olthoff D, Kaisers UX, Rüffert H: **Propofol versus flunitrazepam for inducing and maintaining sleep in postoperative ICU patients**. *Indian J Crit Care Med* 2014, **18**(4):212-219.

7. Roche Campo F, Drouot X, Thille AW, Galia F, Cabello B, d'Ortho M-P, Brochard L: **Poor sleep quality is associated with late noninvasive ventilation failure in patients with acute hypercapnic respiratory failure**. *Crit Care Med* 2010, **38**(2):477-485.

8. Chen J-H, Chao Y-H, Lu S-F, Shiung T-F, Chao Y-F: **The effectiveness of valerian acupressure on the sleep of ICU patients: a randomized clinical trial**. *Int J Nurs Stud* 2012, **49**(8):913-920.

9. Frisk U, Nordström G: **Patients' sleep in an intensive care unit--patients' and nurses' perception**. *Intensive Crit Care Nurs* 2003, **19**(6):342-349.

10. Hardin KA, Seyal M, Stewart T, Bonekat HW: **Sleep in critically ill chemically paralyzed patients requiring mechanical ventilation**. *Chest* 2006, **129**(6):1468-1477.

11. Kamdar BB, King LM, Collop NA, Sakamuri S, Colantuoni E, Neufeld KJ, Bienvenu OJ, Rowden AM, Touradji P, Brower RG *et al*: **The effect of a quality improvement intervention on perceived sleep quality and cognition in a medical ICU**. *Crit Care Med* 2013, **41**(3):800-809.

12. McKinley S, Fien M, Elliott R, Elliott D: **Sleep and psychological health during early recovery from critical illness: an observational study**. *J Psychosom Res* 2013, **75**(6):539-545.

13. Simpson T, Lee ER, Cameron C: **Patients' perceptions of environmental factors that disturb sleep after cardiac surgery**. *Am J Crit Care* 1996, **5**(3):173-181.

14. Fanfulla F, Ceriana P, D'Artavilla Lupo N, Trentin R, Frigerio F, Nava S: **Sleep disturbances in patients admitted to a step-down unit after ICU discharge: the role of mechanical ventilation**. *Sleep* 2011, **34**(3):355-362.

15. Little A, Ethier C, Ayas N, Thanachayanont T, Jiang D, Mehta S: **A patient survey of sleep quality in the Intensive Care Unit**. *Minerva Anestesiol* 2012, **78**(4):406-414.

16. Ehlers VJ, Watson H, Moleki MM: **Factors contributing to sleep deprivation in a multidisciplinary intensive care unit in South Africa**. *Curationis* 2013, **36**(1):E1-8.

17. Uğraş GA, Oztekin SD: **Patient perception of environmental and nursing factors contributing to sleep disturbances in a neurosurgical intensive care unit**. *Tohoku J Exp Med* 2007, **212**(3):299-308.

18. Zhang L, Sha YS, Kong QQ, Woo JA-L, Miller AR, Li HW, Zhou LX, Zhou Y, Wang CL: **Factors that affect sleep quality: perceptions made by patients in the intensive care unit after thoracic surgery**. *Support Care Cancer* 2013, **21**(8):2091-2096.

19. Jones C, Dawson D: **Eye masks and earplugs improve patient's perception of sleep**. *Nurs Crit Care* 2012, **17**(5):247-254.

20. Hofhuis JGM, Spronk PE, van Stel HF, Schrijvers AJP, Rommes JH, Bakker J: **Experiences of critically ill patients in the ICU**. *Intensive Crit Care Nurs* 2008, **24**(5):300-313.

21. Elliott R, McKinley S, Cistulli P, Fien M: **Characterisation of sleep in intensive care using 24-hour polysomnography: an observational study**. *Crit Care* 2013, **17**(2):R46.

22. Elliott R, Rai T, McKinley S: **Factors affecting sleep in the critically ill: an observational study**. *J Crit Care* 2014, **29**(5):859-863.

23. Freedman NS, Gazendam J, Levan L, Pack AI, Schwab RJ: **Abnormal sleep/wake cycles and the effect of environmental noise on sleep disruption in the intensive care unit**. *Am J Respir Crit Care Med* 2001, **163**(2):451-457.

24. Yinnon AM, Ilan Y, Tadmor B, Altarescu G, Hershko C: **Quality of sleep in the medical department**. *Br J Clin Pract* 1992, **46**(2):88-91.

25. Hu RF, Jiang XY, Chen J, Zeng Z, Chen XY, Li Y, Huining X, Evans DJ: **Non-pharmacological interventions for sleep promotion in the intensive care unit**. *Cochrane Database Syst Rev* 2015(10):Cd008808.

26. Kondili E, Alexopoulou C, Xirouchaki N, Georgopoulos D: **Effects of propofol on sleep quality in mechanically ventilated critically ill patients: a physiological study**. *Intensive Care Med* 2012, **38**(10):1640-1646.

27. Treggiari-Venzi M, Borgeat A, Fuchs-Buder T, Gachoud JP, Suter PM: **Overnight sedation with midazolam or propofol in the ICU: effects on sleep quality, anxiety and depression**. *Intensive Care Med* 1996, **22**(11):1186-1190.

28. Parthasarathy S, Tobin MJ: **Effect of ventilator mode on sleep quality in critically ill patients**. *Am J Respir Crit Care Med* 2002, **166**(11):1423-1429.

29. Andréjak C, Monconduit J, Rose D, Toublanc B, Mayeux I, Rodenstein D, Jounieaux V: **Does using pressure-controlled ventilation to rest respiratory muscles improve sleep in ICU patients?** *Respir Med* 2013, **107**(4):534-541.

30. Toublanc B, Rose D, Glérant J-C, Francois G, Mayeux I, Rodenstein D, Jounieaux V: **Assist-control ventilation vs. low levels of pressure support ventilation on sleep quality in intubated ICU patients**. *Intensive Care Med* 2007, **33**(7):1148-1154.

31. Alexopoulou C, Kondili E, Vakouti E, Klimathianaki M, Prinianakis G, Georgopoulos D: **Sleep during proportional-assist ventilation with load-adjustable gain factors in critically ill patients**. *Intensive Care Med* 2007, **33**(7):1139-1147.

32. Bosma K, Ferreyra G, Ambrogio C, Pasero D, Mirabella L, Braghiroli A, Appendini L, Mascia L, Ranieri VM: **Patient-ventilator interaction and sleep in mechanically ventilated patients: pressure support versus proportional assist ventilation**. *Crit Care Med* 2007, **35**(4):1048-1054.

33. Cabello B, Thille AW, Drouot X, Galia F, Mancebo J, d'Ortho M-P, Brochard L: **Sleep quality in mechanically ventilated patients: comparison of three ventilatory modes**. *Crit Care Med* 2008, **36**(6):1749-1755.

34. Drouot X, Bridoux A, Thille AW, Roche-Campo F, Cordoba-Izquierdo A, Katsahian S, Brochard L, d'Ortho M-P: **Sleep continuity: a new metric to quantify disrupted hypnograms in non-sedated intensive care unit patients**. *Crit Care* 2014, **18**(6):628.

35. Córdoba-Izquierdo A, Drouot X, Thille AW, Galia F, Roche-Campo F, Schortgen F, Prats-Soro E, Brochard L: **Sleep in hypercapnic critical care patients under noninvasive ventilation: conventional versus dedicated ventilators**. *Crit Care Med* 2013, **41**(1):60-68.