The Impact of Introducing Nurse-Led Analgesia and Sedation Guidelines in Ventilated Infants following Cardiac Surgery

Implications for Clinical Practice

PICU nurses have an integral role in the judicious administration of analgesia and sedation, while maintaining patient comfort.

The introduction of nurse-led analgesia and sedation guidelines may be associated with an altered pattern but not a decrease in morphine administered to infants post cardiac surgery

Guideline introduction may be associated with greater use of sedatives and co analgesia to meet a prescribed comfort level

The incorporation of nurse-led analgesia and sedation guidelines may be associated with a shorter duration of mechanical ventilation in infants with Trisomy 21 post cardiac surgery

**Introduction**

Critically ill children in paediatric intensive care units (PICU) routinely receive analgesics and sedatives to prevent pain and anxiety, ensuring the security of invasive lines, endotracheal tube and monitoring equipment. While analgesia and sedation administration may be considered a fundamental role of the PICU nurse, there is wide variability in the clinical management of analgesia and sedation therapy across individual PICUs. This is often due to individual or institutional preferences, or custom and practice (Deeter et al. , 2011, Harris and Tume, 2011). Achieving optimal sedation targets in PICU patients can be challenging, which can result in under-sedation, or more commonly, over-sedation. The risks associated with over-sedation include prolonged PICU stay, tolerance and iatrogenic withdrawal syndrome (Vet et al. , 2013).

Consensus recommendations from the European Society of Paediatric and Neonatal Intensive Care (ESPNIC) advocate a standardised approach in analgesic and sedative management in the PICU, with comprehensive patient assessment using a validated tool (Harris et al. , 2016). A current evidence base for a standardised approach is lacking. A systematic review by Poh et al. , (2014) determined an association between use of PICU sedation guidelines, protocols or algorithms (sGPA) and decreased sedation dose and PICU length of stay. In contrast, a multicenter study showed no difference in duration of mechanical ventilation in critically ill children managed with a sedation protocol versus usual care (Curley et al. , 2015).

Many post-operative congenital cardiac surgery patients share important characteristics, including age and type of surgery (i.e. many undergo sternotomy and cardio-pulmonary bypass). Within the Irish population Trisomy 21 is strongly represented, with an incidence of 1 in 546 live births (Ni She and Filan, 2014), compared with 1 in 691 live births in the United States (Parker et al. , 2010). There is a prevalence of 51% for congenital heart disease in this population (Ni She and Filan, 2014) and patients with Trisomy 21 have been reported as having a greater post-operative need for analgesia and sedation (Gakhal et al. , 1998, Mitchell et al. , 1995). This previously held view was not substantiated in subsequent clinical studies (Valkenburg et al. , 2012, Van Driest et al. , 2013, Terada et al. , 2016, Valkenburg et al. , 2016). However the impact of analgesia and sedation guidelines on the Trisomy 21 cohort compared with a non-Trisomy 21 post-op cardiac cohort has not been investigated.

The primary objective of this study was to determine if the introduction of a standardised nurse-led analgesia and sedation practice which incorporates a validated pain and distress instrument, would impact on the amount of morphine administered in the first 72 hours in a population of post cardiac PICU patients. A secondary objective was to ascertain whether there would be a difference in the amount of morphine administered to patients with Trisomy 21 after cardiac surgery.

**Intervention**

The setting for this study was a 23-bed PICU, of a university affiliated teaching hospital. This study concerns the management of analgesia and sedation in the immediate post-operative period; from the point of handover from the operating theatre nurse to 72 hours post-operatively. Widespread variability in analgesia and sedation management practices prompted guideline development by the multidisciplinary PICU Pain and Sedation Group. A six month education campaign with mandatory staff training was undertaken on the new guideline (see table 1). The guidelines required using the COMFORT Behaviour (COMFORT-B) scale which incorporates a Numerical Rating Scale (NRS) (Dorfman et al. , 2014, Harris et al. , 2016). All staff received a two hour training session in guideline use and distress assessment using COMFORT-B by using both videotaped instruction and by performing 10 bedside assessments with an “expert”. Scores were recorded and Cohen’s kappa calculated. A linearly weighted Cohen’s Kappa of >0.65 indicated competency in using COMFORT-B. Training sessions were delivered during the day shift and offered at night shift to accommodate all staff, and ensure all nurses and doctors were signed off as competent.

**Analgesia and Sedation Guidelines**

The analgesia and sedation guidelines required an initial post-operative distress assessment using COMFORT-B, subsequent 2-hourly assessment in the initial 8 hour post-operative period and 2-4 hourly assessments thereafter. Morphine doses were specified according to patient weight (see Analgesia and Sedation Guideline, figure 1). A morphine loading dose at commencement of infusion therapy was indicated to achieve therapeutic concentrations, morphine infusion rates were capped according to patient weight, and as-required, or pre-emptive morphine bolus dosing amounts specified. Administration of intravenous acetaminophen was indicated 6-hourly post-operatively, followed by regular oral dosing on availability of the enteral route. If not contra-indicated a non-steroidal anti-inflammatory agent (NSAID) was recommended. IV midazolam or enteral chloral hydrate was prescribed if sedation was required. Weaning of intravenous morphine was specified after the immediate post-operative period, whereby transition to oral morphine then occurred. Clonidine was indicated as a weaning adjunct. Nurses in the PICU used both the COMFORT-B scale which incorporates a Visual Analogue Scale (VAS) to determine the numeric rating of pain, to assess pain and distress (see figure 2). A COMFORT-B score of > 17 with an NRS value of > 4 indicated the presence of pain, while a COMFORT-B score of > 17 with an NRS <4 suggested under-sedation. After the immediate 6-8 hour post-operative period, COMFORT-B score of <10, suggesting over-sedation prompted a controlled wean of analgesia and/or sedation according to the duration of therapy. The PICU Research Nurse and Pharmacist were responsible for guideline adherence surveillance by reviewing patient charts daily. Compliance with maximum guideline morphine infusion rates, frequency of distress assessment and prescription of adjunct and co-analgesia as well as morphine boluses were closely monitored.

**Methods**

A retrospective before / after study design was used. Ethical approval for conducting the study was obtained (GEN/12809). All patients admitted to the PICU within the defined time periods meeting the inclusion criteria were included in the study. Patients aged between 44 weeks post-conceptual age and one-year post-partum who had open cardiothoracic surgery were included. Children previously ventilated, previously exposed to opiates, possessing a documented opioid sensitivity, requiring Extra Corporeal Life Support (ECLS) therapy, children with a confirmed neuro-developmental pathology, those with a documented genetic disorder (aside from Trisomy 21), and patients receiving neuromuscular blockade were excluded from the study.

A sample size calculation was performed, based on a study by Jin et al. , (2007) assessing the impact of a sedation protocol on opioid administration in PICU patients. Jin’s study reported a sample size totalling 40 patients as sufficient to demonstrate a 300 mcg/kg reduction in total dose of fentanyl after sedation protocol introduction, with 80% power and a 2-tailed level of significance of 0.05. Based on Jin et al’s. , (2007) paper and using a 100:1 IV morphine to IV fentanyl conversion, our sample size of 125 had almost 100% power.

Data collection for the pre-intervention period included patients meeting inclusion criteria over a one year period immediately prior to mandatory staff training sessions in advance of the change in practice commenced. After a five month bedding-in period of the changed approach to analgesia and management, data collection for the post-intervention period commenced. This patient group was managed in accordance with the study protocol for the changed approach to analgesia and sedation management. A one-year data collection period was chosen both before and after the intervention, and no other significant institutional or patient care changes occurred during the study period. Data collection for this study was completed in 2014, and the guidelines as well as analgesics and sedative agents described continue to be used in the PICU to good effect. Demographic data and medical history were collected, as well as cardiac lesion type; Risk Adjustment for Congenital Heart Surgery (RACHS) score (Al-Radi et al. , 2007), duration of cardio-pulmonary bypass and cross clamp time. Severity of illness on admission to PICU was recorded as Paediatric Index of Mortality recalibrated (PIM2) and daily Paediatric Logistic Organ Dysfunction (PELOD) scores to reflect severity of illness over PICU stay (Leteurtre et al. , 2003, Slater et al. , 2003), duration of mechanical ventilation and length of PICU stay.

The first 72 hours post-operatively was divided into 3 phases to reflect the dynamics of postoperative recovery. Phase 1 referred to the first 24 hours post-op, phase 2 referred to the >24 - 48 hour post-operative period, while phase 3 referred to the >48-72 hour period post-operatively. Doses of morphine (microgram-per-kg) including large intra-operative doses to achieve a therapeutic concentration, morphine administered via continuous infusion and intravenous bolus were collected. Bolus and infusion morphine doses were calculated on a microgram-per-kg basis per patient for each of the 3 post-operative phases. Administered dosages of the six primary analgesics and sedatives used in each of the 3 phases were collected. These included acetaminophen, non-steroidal anti-inflammatory drugs (NSAIDS), clonidine, midazolam, oral morphine sulphate and chloral hydrate. COMFORT-B and NRS pain scores were collected for the post-intervention group only, as no formal pain or sedation scoring tool was in use in the pre-intervention period.

**Data Analysis**

Data were analysed using SPSS version 24.0 (IBM, Chicago, IL). Data were descriptively analysed, and normality determined through inspection of histograms. Categorical data between the before and after groups were compared using the Chi-square test. The *t-*test was used to test differences in group means; these data are presented as mean values with standard deviations. Variables not normally distributed were compared using the Mann-Whitney-U test. Multiple regression analyses modelling of the outcome (morphine administered in the first 48 hours postoperatively) was performed with the covariates of Trisomy 21 diagnosis and position in either the before or after grouping. Analysis was performed to determine differences in morphine, sedative and co-analgesic administration. All *p* values of <0.05 (two tailed) were considered statistically significant.

**Results**

150 eligible patients were identified for inclusion, of which 125 provided sufficient data for analysis: 61 pre-intervention and 64 post-intervention (figure 3). The demographic and clinical characteristics of both groups are listed in Table 2. Patients in the before group had a lower gestational age than those in the after group (38.3 weeks vs 40 weeks (p=0.02)). There was a higher proportion of patients with Trisomy 21 in the before group (54% vs 35.9% p=0.049). The groups were otherwise clinically and demographically comparable.

The rate of morphine infusing on arrival of the patient to PICU post cardiac surgery reduced significantly from a median (IQR) of 80 mcg/kg/hr (40-80) in the pre-intervention group to 40 mcg/kg/hr (40-80) (p<0.001) in the post-intervention group (See Figure 4 Illustrating Morphine Infusion Rate on Return from Operating Theatre, Pre-and Post-Intervention). Following the intervention, significantly more patients in the post-intervention group received morphine boluses during phase 1 and phase 2 than in the pre-intervention group (p<0.001). Despite these variances, there was no statistically significant difference in total morphine administered over the first 72 hours after surgery between the pre and post-intervention groups (987 mcg/kg, IQR 730 - 1637) versus post (949 mcg/kg, IQR 731 - 1314), p=0.46 (See Table 3: Postoperative Analgesia and Sedation administered to ‘Before’ and ‘After’ Groups).

Total amounts of morphine administered to patients with and without Trisomy 21 were compared. No significant differences emerged between the groups either before (p=0.9), or after the intervention (p=0.08). Furthermore, no differences were found in morphine administered to patients with Trisomy 21 before versus after the intervention (p=0.15).

Analysis of co analgesia revealed significantly higher acetaminophen administration in phase 1 after the intervention, compared with before (p<0.001). Examination of oral sedation revealed significantly higher clonidine doses were administered after the intervention in phase 2 (p=0.014). Significantly more patients were receiving clonidine in all phases after the intervention (p=0.001, p<0.001, p=0.037, for phases 1, 2 and 3, respectively). Before the change in practice patients with Trisomy 21 received significantly more chloral hydrate than patients without Trisomy 21 in phase 2 (*p*<0.05) and 3 post-operatively (*p*=0.004). After the intervention there was no longer a significant difference between the amount of chloral hydrate administered to study patients with and without Trisomy 21 (*p*=0.29). Patients with Trisomy 21 experienced a statistically significant decrease in duration of mechanical ventilation after the intervention from 34 hours to 25.1 hours (*p*=0.012) (figure 4). The median duration of mechanical ventilation decreased from 30.5 hours to 25.7 hours (*p*=0.07) after the intervention for patients without Trisomy 21, not meeting the threshold of statistical significance.

COMFORT-B and NRS scores were only available after the intervention. For the 64 subjects a total of 672 distress assessments were conducted. Over three quarters of the assessments (75.6%, n=405 scores) determined a comfortable non-distressed state (COMFORT-B score <17, NRS <4). In a quarter of cases (24.9%, n=168 scores) a distressed state due to pain was confirmed (COMFORT-B score ≥17, NRS ≥4). COMFORT-B scores were significantly higher in phase 1 compared to phases 2 and 3 (n=14 2.1%, n=6 0.9% and n=2 0.3% respectively) (p=0.007). A COMFORT-B < 11, suggesting over-sedation was more common in phase 1 (n=31 4.6%, n=16 2.4% and n=9 1.3% in the respective phases 1 to 3). A COMFORT-B score ≥ 17 combined with an NRS <4, indicating non-pain related distress was more common in phase 1 (n=23 3.4%, n=16 2.4% and n=9 1.3% phases 1-3 respectively). There was no significant difference in the incidence of pain (p=0.95) or over-sedation (p=0.68) between patients with Trisomy 21 and those without.

Discrete elements of the guidelines were measured to reflect adherence with the change in practice (see figure 5). Patients had a pain and distress assessment carried out within 2 hours of returning from theatre in 70.3% (n=45) of cases, and in 90.6% (n=58) of cases IV morphine boluses were prescribed on a PRN basis, compared with 8.2 % (n=5) before the change in practice. In 90.6% (n=58) of cases non-opioid analgesia was prescribed for patients after the change in practice, compared with 26.2% (n=16) before the intervention.

**Discussion**

This study showed morphine infusion rates were significantly lower after the change in practice, demonstrating good adherence to maximum guideline infusion rates. While morphine remains the primary analgesic after cardiac surgery due to its efficacy, the pharmacokinetic and pharmacodynamic susceptibility of the neonate to opioids is well acknowledged (Wolf and Jackman, 2011). A departure from practice from morphine delivery by high rate infusion is welcome, given awareness of the neurotoxic effects of some anaesthetics and analgesics including morphine on the developing brain (Mellon et al. , 2007, Rappaport et al. , 2011). Such information has raised awareness of analgesia and sedation management in vulnerable neonatal cohorts. In light of this, expert consensus supports administering a dose sufficient to reduce discomfort to an acceptable level without the side effects of therapy (Harris et al. , 2016). Findings from this study also indicated after the intervention morphine boluses were more frequently administered. This suggests patients were receiving morphine analgesia based on clinical need, as determined by assessment using a validated instrument, rather than an overreliance on delivery by high rate infusion. Any expected reduction in overall morphine administration after guideline introduction may have been counterbalanced by this increase in administration of morphine boluses. This may have resulted in no alteration in overall morphine administered. Internationally, contrasting findings are reported on the impact of nurse-led analgesia and sedation guidelines on morphine administration in PICUs. These range from significantly higher median dosages after guideline introduction (Ista et al. , 2009), significant decreases in duration of morphine infusion duration (Curley et al. , 2015) and no significant differences in opioids administered or duration of therapy (Dreyfus et al. , 2017, Keogh et al. , 2014, Neunhoeffer et al. , 2015). Differences in analgesia and sedation practices within and across PICUs are well acknowledged (Gopisetti and Playfor, 2015). Any observed changes after an alteration in analgesia and sedation practice has been introduced are likely to be influenced by baseline unit-based variations in practice. These include the primary analgesic and sedative agents used, nurse-autonomy in altering infusion rates and administering bolus doses.

Differences in post-operative opioid dosages between patients with and without Trisomy 21 were not identified. This is consistent with recent research reporting comparable pain scores, morphine requirements and duration of mechanical ventilation between patients with and without Trisomy 21 post cardiac surgery (Valkenburg et al. , 2016). Previous studies reported patients with Trisomy 21 had longer hospitalisation than non-Trisomy 21 matched controls after cardiac surgery (Van Driest et al. , 2013). In contrast, after the change in practice in the current study: patients with Trisomy 21 had a significantly shorter duration of mechanical ventilation. This finding may be a result of the Trisomy 21 cohort benefitting from a standardised, evidence based approach to analgesia and sedation management, particularly in relation to the oral sedative chloral hydrate, a synthetic sedative-hypnotic. The current study observed patients with Trisomy 21 received significantly less chloral hydrate, after the intervention compared to before. In addition patients with Trisomy 21 were no longer receiving higher doses of this sedative than non-Trisomy 21 patients after the intervention, as they had been before. This novel finding suggests that the Trisomy 21 paediatric population may benefit from a structured approach to analgesia and sedation management. It could be argued that the use of a validated distress assessment tool to guide analgesia and sedation administration prompted more conservative sedative use in this cohort.

This study found the pattern of administration of analgesia and sedation was significantly altered after the intervention. This included greater utilisation of co analgesia such as acetaminophen and clonidine. A Dutch study by Ista et al. , (2009) reported patients received additional agents including esketamine, clonidine, acetominophen and alimemazine following the introduction of a sedation protocol. In our study, over twice as many patients received clonidine after the intervention in the first 48 hours postoperatively without a decrease in total morphine administered. This is at odds with previous observations which reported that use of clonidine was synonymous with decreased average hourly requirements for morphine in PICU (Arenas-Lopez et al. , 2004, Lyons et al. , 1996). This study revealed a willingness among PICU nurses to administer co analgesia and sedation supported by clinical guidelines. An increased awareness and usage of adjunct medications to complement or replace intravenous morphine in PICU patients after analgesia and sedation guideline introduction has previously been reported (Keogh et al. , 2015). Co analgesia with NSAIDS and acetaminophen play a vital role in reducing opioid requirements and side effects, particularly tolerance and iatrogenic withdrawal syndrome, contributing to enhanced patient outcomes (Wolf and Jackman, 2011). Although the nature of patient’s altered opioid exposure in this study may have been greatly affected by additional agents including alpha-agonists, use of agents such as acetaminophen and clonidine have favourable side effect profiles. Patients experiences of iatrogenic withdrawal syndrome, tolerance and delirium are not reported in the study. A behavioural tool capable of distinguishing between withdrawal, delirium and post traumatic distress does not exist currently, however a withdrawal assessment tool and delirium protocol have been introduced subsequent to the study taking place.

Although distress assessment prior to implementation of the guidelines was not formally measured, the mean number of distress assessments conducted after implementation of the analgesia and sedation guidelines in this study was 10.5 (672 assessments in 64 subjects). Previous research, (Ista et al. , 2009) reported the mean number of assessments as 11 before, and increasing to 12 after the introduction of a sedation protocol. Of note three quarters of study patients were adequately sedated in the current study compared with 64% in the study conducted by Ista et al. , (2009). This finding suggests analgesics and sedatives were being managed to good effect. As a formal distress assessment tool was not in place in the study setting before the change in practice, pre- and post-intervention distress assessment comparisons are not possible. As the study population were pre-verbal ventilated infants, incapable of self-report, PICU nurses may have previously relied on behavioural and physiological to guide their treatment interventions (LaFond et al. , 2015). Using such cues in distress assessment is not recommended, as vital sign changes are not specific to distress in critically ill children (Ista et al. , 2005). The validation and acceptance of the COMFORT-B distress assessment has demonstrated a high quality of psychometric evidence and allowed quantifiable and systematic distress assessment to guide clinical decision making (Ge et al. , 2017). Adherence to specific measurable aspects of the analgesia and sedation guidelines largely confirmed their adoption into practice in the study site (figure 5). Furthermore, an increase in PICU staff satisfaction with analgesia and sedation management after this change in practice at the study site has previously been reported (Magner et al. , 2018). The value of the PICU nurse acting autonomously in evaluating patient’s distress status and adapting therapeutic interventions is well acknowledged (Dreyfus et al. , 2017, Keogh et al. , 2014), given their proximity to and knowledge of the patient.

**Limitations**

This study was a retrospective single centre study, limiting its generalisability. A further limitation was the use of before/after methodology, as in the majority of precedent studies. Although there were no significant staff or practice changes during the study period, temporal trends may have influenced our results. While an RCT approach was considered, the change intervention involved required large scale and resource intensive education and awareness initiatives for all PICU staff, rendering randomisation unfeasible. A more comprehensive capture of non-compliance and poor guideline adherence was desirable, and considered a study limitation. An absence of formal pain and distress assessment in the PICU prior to guideline implementation prevented the full appreciation of the impact of this intervention. Patients with Trisomy 21 were over-represented in the pre-intervention group. The sample size also limited use of a more comprehensively matched cohort design.

**Conclusion**

Findings from this study support responsibility for PICU nurses for autonomously administering analgesia and sedation based on validated assessment, supported by clinical guidelines. While a demonstrable impact on the primary outcome was not evident in this study, an altered pattern of morphine administration emerged; characterised by lower infusion rates and greater use of boluses based on patient assessment. The pattern of specific co analgesic and sedation administration was also significantly altered, reflecting medication administration to meet a prescribed comfort level.

These findings affirm the PICU nurses’ impact in effectively managing prescribed analgesia and sedation in a judicious manner, while maintaining patient comfort. Findings from this study add to the body of evidence refuting that Trisomy 21 patients have increased sedation and analgesic requirements compared to the general PICU population. This cohort demonstrated a reduction in duration of mechanical ventilation after the change in practice. A continued education and awareness focus must continue to support an evidence based approach to analgesia and sedation management in PICU in the ultimate pursuit of quality patient care.

References

Al-Radi OO, Harrell FE, Jr., Caldarone CA, McCrindle BW, Jacobs JP, Williams MG, et al. Case complexity scores in congenital heart surgery: a comparative study of the Aristotle Basic Complexity score and the Risk Adjustment in Congenital Heart Surgery (RACHS-1) system. J Thorac Cardiovasc Surg. 2007;133:865-75.

Arenas-Lopez S, Riphagen S, Tibby SM, Durward A, Tomlin S, Davies G, et al. Use of oral clonidine for sedation in ventilated paediatric intensive care patients. Intensive care medicine. 2004;30:1625-9.

Curley MA, Wypij D, Watson RS, Grant MJ, Asaro LA, Cheifetz IM, et al. Protocolized sedation vs usual care in pediatric patients mechanically ventilated for acute respiratory failure: a randomized clinical trial. Jama. 2015;313:379-89.

Deeter KH, King MA, Ridling D, Irby GL, Lynn AM, Zimmerman JJ. Successful implementation of a pediatric sedation protocol for mechanically ventilated patients. Critical care medicine. 2011;39:683-8.

Dorfman TL, Sumamo Schellenberg E, Rempel GR, Scott SD, Hartling L. An evaluation of instruments for scoring physiological and behavioral cues of pain, non-pain related distress, and adequacy of analgesia and sedation in pediatric mechanically ventilated patients: A systematic review. International journal of nursing studies. 2014;51:654-76.

Dreyfus L, Javouhey E, Denis A, Touzet S, Bordet F. (2017). Implementation and evaluation of a paediatric nurse-driven sedation protocol in a paediatric intensive care unit. Annals of Intensive Care.2017;7: 36.

Gakhal B, Scott CS, MacNab AJ. Comparison of morphine requirements for sedation in Down's syndrome and non-Down's patients following paediatric cardiac surgery. Paediatric anaesthesia. 1998;8:229-33.

Ge X, Zhang T, Zhou, L. Psychometric analysis of subjective sedation scales used for critically ill paediatric patients. Nursing in Critical Care. 2017;23:30-41.

Gopisetti S, Playfor SD. Sedation and Analgesia for Critically Ill Children. Paediatrics and Child Health. 2015; 25,5:224-9.

Harris J, Tume L. UK and Ireland Audit in analgesia and sedation practices in PICU. Paediatric Intensive Care Society Annual Conference. Hamburg, Germany 2011.

Harris J, Ramelet AS, van Dijk M, Pokorna P, Wielenga J, Tume L, et al. Clinical recommendations for pain, sedation, withdrawal and delirium assessment in critically ill infants and children: an ESPNIC position statement for healthcare professionals. Intensive care medicine. 2016;42:972-86.

Ista E, van Dijk M, Tibboel D, de Hoog M. (2005). Assessment of sedation levels in pediatric intensive care patients can be improved by using the COMFORT "behavior" scale. Pediatric Critical Care Medicine. 2005;6:58–63.

Ista E, de Hoog M, Tibboel D, van Dijk M. Implementation of standard sedation management in paediatric intensive care: effective and feasible? Journal of clinical nursing. 2009;18:2511-20.

Jin HS, Yum MS, Kim SL, Shin HY, Lee EH, Ha EJ, et al. The efficacy of the COMFORT scale in assessing optimal sedation in critically ill children requiring mechanical ventilation. Journal of Korean medical science. 2007;22:693-7.

Keogh S, Long D, Horn D. Practice guidelines for sedation and analgesia management of critically ill children: a pilot study evaluating guideline impact and feasibility in the PICU. BMJ Open. 2015;e006428.

LaFond C, van Hulle Vincent C, Corte C, Hershberger P, Johnson A, Park C, et al. PICU Nurses' Pain Assessments and Intervention Choices for Virtual Human and Written Vignettes. 2015;30:580-590. Leteurtre S, Martinot A, Duhamel A, Proulx F, Grandbastien B, Cotting J, et al. Validation of the paediatric logistic organ dysfunction (PELOD) score: prospective, observational, multicentre study. Lancet. 2003;362:192-7.

Lyons B, Casey W, Doherty P, McHugh M, Moore KP. Pain relief with low-dose intravenous clonidine in a child with severe burns. Intensive care medicine. 1996;22:249-51.

Magner C, Van Dijk M, Cowman S. Introducing PICU Analgesia and Sedation Guidelines, Staff Satisfaction Before and After the Practice Change. Pediatric Intensive Care Nursing. 2018;19:2-13.

Mellon RD, Simone AF, Rappaport BA. Use of anesthetic agents in neonates and young children. Anesthesia and analgesia. 2007;104:509-20.

Mitchell V, Howard R, Facer E. Down's syndrome and anaesthesia. Paediatric anaesthesia. 1995;5:379-84.

Neunhoeffer F, Kumpf M, Renk, H, Hanelt M, Berneck N, Bosk A, et al. Nurse-driven pediatric analgesia and sedation protocol reduces withdrawal symptoms in critically ill medical pediatric patients. Pediatric Anesthesia. 2015;25;786–794.

Ni She R, Filan P. Trisomy 21: incidence and outcomes in the first year in Ireland today. Irish Medical Journal. 2014;107:248-9.

Parker SE, Mai CT, Canfield MA, Rickard R, Wang Y, Meyer RE, et al. Updated National Birth Prevalence estimates for selected birth defects in the United States, 2004-2006. Birth Defects Res A Clin Mol Teratol. 2010;88:1008-16.

Poh YN, Poh PF, Buang SN, Lee JH. Sedation guidelines, protocols, and algorithms in PICUs: a systematic review. Pediatric critical care medicine : a journal of the Society of Critical Care Medicine and the World Federation of Pediatric Intensive and Critical Care Societies. 2014;15:885-92.

Rappaport B MD, Simone A, Woodcock J Defining safe use of anaesthesia in children. . New England Journal of Medicine. 2011;364:1387-90.

Slater A, Shann F, Pearson G, Paediatric Index of Mortality Study G. PIM2: a revised version of the Paediatric Index of Mortality. Intensive care medicine. 2003;29:278-85.

Terada Y, Tachibana K, Takeuchi M, Kinouchi K. Comparison of sedative and analgesic requirements in children with and without Down Syndrome following pediatric cardiac surgery. Masui The Japanese Journal of Anesthesiology. 2016;65:56-61.

Valkenburg AJ, Calvier EA, van Dijk M, Krekels EH, O'Hare BP, Casey WF, et al. Pharmacodynamics and Pharmacokinetics of Morphine After Cardiac Surgery in Children With and Without Down Syndrome. Pediatric critical care medicine : a journal of the Society of Critical Care Medicine and the World Federation of Pediatric Intensive and Critical Care Societies. 2016;17:930-8.

Valkenburg AJ, van Dijk M, de Leeuw TG, Meeussen CJ, Knibbe CA, Tibboel D. Anaesthesia and postoperative analgesia in surgical neonates with or without Down's syndrome: is it really different? Br J Anaesth. 2012;108:295-301.

Van Driest SL, Shah A, Marshall MD, Xu H, Smith AH, McGregor TL, et al. Opioid use after cardiac surgery in children with Down syndrome. Pediatric critical care medicine: a journal of the Society of Critical Care Medicine and the World Federation of Pediatric Intensive and Critical Care Societies. 2013;14.

Vet NJ, Ista E, de Wildt SN, van Dijk M, Tibboel D, de Hoog M. Optimal sedation in pediatric intensive care patients: a systematic review. Intensive care medicine. 2013;39:1524-34.

Wolf AR, and Jackman L. Analgesia and Sedation after Pediatric Cardiac Surgery. Pediatric Anesthesia. 2011;21: 567-576.

Tables and Figures

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