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1 **Current practice of preparing morphine infusions for nurse/patient controlled**  
2 **analgesia in a UK paediatric hospital: healthcare professionals' views and**  
3 **experiences**

4

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43 **Abstract**

44

45 **Objective**

46 To explore the views and experiences of healthcare professionals (HCPs) regarding the  
47 preparation of morphine infusions for nurse/patient controlled analgesia (N/PCA).

48

49 **Methods**

50 Three focus groups were conducted with HCPs (anaesthetists, nurses in theatres and  
51 wards) at one UK children's hospital. Focus groups were transcribed verbatim and content  
52 analysis was used to identify themes.

53

54 **Results**

55 A variety of approaches are used to prepare morphine infusions. A lack of appreciation of  
56 the excess volume present in morphine ampoules that nominally contain 1 or 2 mL was  
57 identified. Other sources of error were miscalculation, complexity of the multi-step  
58 procedure, distractions and time pressure. Participants suggested that 'ready-to-use'  
59 prefilled syringes and pre-programmed syringe pumps would improve practice and minimise  
60 the risk of error.

61

62 **Conclusion**

63 Risks associated with the preparation of infusions for paediatric N/PCA, in particular non-  
64 appreciation of the overage (excess volume) in morphine ampoules, raises concerns about  
65 the accuracy of current practices.

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71 **What is already known on this subject**

- 72 • It is well recognised that preparing intravenous infusions for children is a complex  
73 process which poses serious risks, especially when preparing potent medicines.
- 74 • Currently there is no standard preparation method that healthcare professionals can  
75 follow when preparing morphine intravenous infusions for nurse/patient controlled  
76 analgesia for children.

77

78 **What this study adds**

- 79 • This study found deficiencies in HCPs knowledge of how to perform accurate infusion  
80 preparation. Amongst other factors, we identified an unexpected lack of appreciation  
81 of the 'overage' (excess volume) present in morphine ampoules. New, safer  
82 procedures are recommended to improve the current practice of preparing  
83 intravenous morphine infusions for children, for example programmable infusion  
84 pumps in tandem with 'ready-to-use' preparations of standardised concentrations.

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98 **INTRODUCTION**

99 The process of preparing and administering an intravenous drug is complex with multiple  
100 error-prone steps, which may lead to mistakes that have serious adverse outcomes for  
101 patient.[1]

102

103 Unlike adult practice, where most patients receive standard concentration drug infusions,  
104 nurse- and/or patient-controlled analgesia (N/PCA) for children is prepared as an  
105 'individually made product', i.e. prepared for each patient based on their age or weight. This  
106 is done by using the "rule of 6" formula [2] to calculate the infusion concentrations prescribed  
107 in micrograms per kilogram per minute. This formula is described as: 6 x patient's weight  
108 (kg) equals the amount of drug in milligrams that should be added to 100 mL of solution,  
109 when administered at 1 mL/h to give an infusion rate of 1 microgram/kg/min.[2]

110

111 The aim of this study was to explore views and experiences of healthcare professionals  
112 (HCPs) on the current practice of preparing morphine infusion for N/PCA use in children and  
113 identify any problems they encountered during preparation and administration.

114

115 **METHODS**

116 Three focus groups were conducted during 2014 with HCPs from three clinical areas at the  
117 Evelina London Children's Hospital (ELCH), paediatric ward nurses, operating theatre  
118 anaesthetists, and recovery nurses. Focus groups were organised to discuss with HCPs  
119 their current practice in preparing morphine infusion for N/PCA, their views and experiences,  
120 and to explore any problems they encountered during preparation and administration.

121

122 Focus group topic guide was developed by the research team, based on local hospital policy  
123 and published literature [1,3-4], covering aspects of current practice in preparing and  
124 administering morphine N/PCA. These included; calculation of drug dose, mixing of  
125 morphine IV injection with diluent, programming the infusion pump, factors contributing to

126 occurrence of morphine N/PCA medication errors, and possible solutions to minimise such  
127 errors. This guide was used by the moderator to guide the discussion, with all three focus  
128 groups undertaken using the same topic guide.

129

130 The focus groups were conducted by two members of the research team (CW-moderator,  
131 ANR–assistant moderator). Focus groups were audio-recorded and recordings transcribed  
132 verbatim (ANR) and validated (CW).

133

### 134 **Data Analysis**

135 An anonymised transcript of each focus group was uploaded to QSR NVivo (version 10)  
136 software for coding and categorisation to identify themes. Qualitative content analysis was  
137 used with three main themes being set *a priori* and supplemented by emergent subthemes  
138 identified during analysis.[5-6] Coding frames were prepared and framework analysis  
139 created by ANR and checked by CW.

140

### 141 **RESULTS**

142 Three separate focus groups (FG) were conducted with participants recruited from the three  
143 different clinical areas; 1) FG with theatres' anaesthetists (n=5), 2) FG with ward nurses  
144 (n=4), 3) FG with recovery nurses (n=5). Each FG was 45-60 minutes duration. All except  
145 one of the participants were female (n=13).

146

147 Three main themes were identified: 1) views on the current practice of preparing morphine  
148 infusions for N/PCA use, 2) problems and factors contributing to errors in current practice, 3)  
149 suggestions to improve current practice and minimise errors. These themes and sub-themes  
150 are summarised in table 1 with illustrative quotes from the focus groups. The individualised  
151 syringe preparation at ward and/or theatre level was not standardised in terms of mixing  
152 drug with diluent, as described by participants. This including the challenge of using different  
153 syringe sizes in one preparation, (table 1).

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157 **Table 1 Summary of topic themes and subthemes identified from the focus groups**

Theme	Subthemes	Example quotes
The current NCA/PCA preparation process	Paper work; prescription, calculation sheet Calculation checking Mixing drug with diluent Programming the pump The double checking process Labelling Changing syringes	<p><i>“There are two pieces of paper work to do this. There is the prescription which goes on the “as required” section of the drug chart. That’s presented as a sticker, so you need to check whether it is the right sticker, and then there is the calculations sheet which also comprises the administration record. So that has a number of calculations to do based on patient’s weight. Once those calculations have been done, then you need to obtain the drugs, the diluent, and then draw it up, and then purge the line, place it in the syringe driver, and programme the syringe driver, then attach it to the patient.”</i> (paediatric anaesthetist-1)</p> <p><i>“our responsibility...we have to change the syringe....but we can’t change any information, on any programme.”</i> (ward nurse-1)</p>
Factors contributing to errors in current practice	Time pressure/busy environment, multitasking Calculations  Wrong labelling Wrong protocol used Wrong programme on pump  Drug ampoule overage  Mixed system used in PICU*  Look-alike error  Use of different syringe sizes in one preparation	<p><i>“We get distracted. There is always other things going on and you get distracted from what you are doing, and there is not always somebody who could actually sit down with you and reliably check all your calculations, so you can get someone to check it on the pump sure, but not necessary, that what I find anyway.”</i> (paediatric anaesthetist-2)</p> <p><i>“We have a variety of errors. It can be; no patient’s identification on the label on the syringe; no signature on the syringe; no dose on the syringe; the wrong sticker be stuck on the chart; occasionally the wrong protocol has been as well, and occasionally sometimes, the programme doesn’t correlate with the protocol. For instance, the protocol may says the background, the programme doesn’t.”</i> (recovery nurse-1)</p> <p><i>“So for example if you need 26 mg in 50 mL, I will draw up two 10s and then I will draw 10 in 10 and take out 6. So that how I do it.”</i> (ODP<sup>1</sup>/recovery nurse-4)</p> <p><i>“Because in the intensive care we have the pain sedation while patients are intubated, we have pre-prepared morphine syringes. That’s what we generally use. Only when we are going to send a child to ward or they come from theatre and then they come with NCA or PCA...”</i> (ward nurse-2)</p> <p><i>“Some drugs draw up to 100 mL bag, and hardly any clear solution come in 100 mL bag, and one of them is metronidazole, so on one occasion the PCA was prepared in metronidazole rather than a saline.”</i> (paediatric anaesthetist-3)</p> <p><i>“I think there is a challenge which I am sure it should have been shown up in the observations, and that is the different syringes, 1 mL, 2 mL, 2.5 mL syringes where you have got to draw up, say, 1.66 mL, do you use a 1 mL-syringe and then 2.5 mL -syringe to do the 1 mL, then 0.66, or do you use the 2.5 mL-syringes. So there will be inconsistency.”</i> (ward nurse-3)</p>

	<p>Delays in obtaining drugs/key/paperwork</p> <p>Not purging the pump</p> <p>Out-of-hours and knowledge of people with the process</p>	<p><i>“Potential for delay and error is if more than one person is involved, like if a trainee would start of the whole process, then we take over or vice versa, but that happened to me when I started the same thing then the trainee took over and then there was an error that I had to correct it later, but it could’ve been potentially dangerous.” (paediatric anaesthetist-1)</i></p> <p><i>“There is one problem that I saw many trainees having. They don’t engage the plunger on the syringe pump, and on very small baby sometimes it takes half a mL or whole mL before it actually starts dripping at the other end, which means that may be 10-15 minutes will pass before they actually get any analgesia. Maybe half an hour if it is small baby.” (paediatric anaesthetist-4)</i></p> <p><i>“Out of hours perhaps is more problematic because you don’t have the pain nurse support... particular during changeover of the doctors, sometimes, information is not related to who they could contact if they have problem.” (recovery nurse-2)</i></p>
<p>Improvements in practice and suggestions to minimise errors</p>	<p>Use PFS<sup>††</sup></p> <p>Separate storage for look-alike drugs and diluents</p> <p>Computer programme for calculations</p> <p>Preparation of N/PCA by recovery nurses</p>	<p><i>“Pre-filled syringes, all the way...Because they will be already made-up, just select the syringe that you want and attach it, there is no faffing around with CD [controlled drug] book checking out the CD, drawing it all up. I mean takes quite time to draw up 49 mL of saline.” (ward nurse-4)</i></p> <p><i>“Could be integrated with EPR [electronic patient record] quite easily...definitely would be part of the electronic prescribing once that’s available” (paediatric anaesthetist-1)</i></p> <p><i>“The only thing that comes to me is something that I’ve done before, but not in paediatric setting in adult setting, where the recovery staff set up the pumps. So it is bit more of a controlled area...I think you can get that where two people step out and do the pump and do the drawing up and then take it into theatre, but then again about you going to connecting up something you don’t know about it.” (recovery nurse-3)</i></p>

\*PFS of morphine standard concentration for continuous infusion and individually prepared concentration for N/PCA; †ODP = Operating department practitioner;

††PFS = pre-filled syringe

158 Lack of appreciation by the HCPs of the volume overage in morphine ampoules was an  
159 emergent theme identified during the focus groups. This was primarily an issue for  
160 anaesthetists in theatres (Box 1), although some nurses also explained they were not aware  
161 that a measured volume must be withdrawn to accurately extract 10 mg morphine from a 10  
162 mg in 1 mL morphine ampoule.

163

164 Box 1: Excerpt of the transcript of the anaesthetists' focus group referring to the actual  
165 volume of solution contained in a morphine ampoule.

166

Anaesthetist 1: *"The ampoules are overfilled. It's supposed to be 10 mg/mL, but there is more than 1 mL in every ampoule."*

Anaesthetist 2: *"Say I've got a 27 kg [weight] child, and you have to put 27 mg in [50 mL]. I'll always put the 20 mg, all of the ampoules in [whole content of 2 ampoules in 50 mL-syringe], as I opposed to drawing it up in a syringe [separate syringe with different size] I will be losing some and I want to make sure that I get what I think in my head is 27 [mg]. So the first 2 [ampoules] will get the full ampoule [whole content of the 2 ampoules] and only [for] the last 7 mg that I will draw [them] up in a 1 mL syringe."*

Anaesthetist 3: *"Yeah, only in round numbers. Like if 30 kg [child's weight], you have 3 ampoules, you put them all [whole content of the 3 ampoules] into the diluent. But if it's 15 kg [weight] baby, you have to have two syringes [2 syringes capacities; one to draw up 1 mL (containing 10 mg) and another to draw up 0.5 mL (containing 5 mg)]."*

167

168 Participants identified several factors that contributed to the occurrence of errors when  
169 preparing morphine infusion for N/PCA such as wrong calculations, wrong label, and using  
170 the wrong protocol, look-alike drugs, inaccurate volume measurement, distractions/busy  
171 environment, delays due to obtaining morphine ampoules, multi-tasking, and time pressures  
172 (Table 1). This is illustrated in the example below.

173 *"I think time could add on in any contributing factor, as time pressures. Basically*  
174 *links to multi-tasking, but time pressure with something, you are doing something,*

175 *you want the child to have pain relief and you want to get on and do it as quickly as*  
176 *possible and I guess all those small things will add on and cause an error; which is a*  
177 *simple calculation of 2, zero, and 1 and 2” (paediatric anaesthetist).*

178 Possible measures to improve practice and minimise errors were identified by participants  
179 such as use of ‘ready-to-use’ prefilled syringes, use of a computer programme for  
180 calculations and use of separate storage for look-alike drugs (Table 1).

181

## 182 **DISCUSSION**

183 This study provides a valuable insight into everyday practice of administering N/PCA for  
184 children. During the focus groups, participants identified several factors that might contribute  
185 to possible medication errors, such as complex calculation, distractions, busy environment,  
186 time pressure, and mixed systems, where prefilled syringe of standard concentration infusion  
187 and individually prepared infusions are both used in the same clinical area. Similar factors  
188 have been reported in previous studies that investigated causes of IV drug preparation  
189 errors.[7-9]

190

191 During the focus group HCPs, predominately the anaesthetists, explained their confusion  
192 about the volume of morphine solution presented in an ampoule, and reported their practice  
193 of withdrawing the entire ampoule contents including the volume overage during their  
194 preparation of morphine infusions. It is possible to draw 1.1 mL out of a 10 mg in 1 mL  
195 ampoule, which would mean that 11 mg are taken, giving a +10% error. This was consistent  
196 with positive deviations in the concentration of morphine infusions prepared by HCPs  
197 (unpublished data by our team).

198

199 The participants in the focus groups identified various strategies to reduce the number of  
200 manipulations required in morphine infusion preparation to minimise the occurrence of  
201 errors. Many of these have been suggested previously. The use of prepared standardised  
202 infusion was one strategy.[8, 10] A study in children identified that the number of reported

203 errors associated with continuous medication infusions was reduced by 73% following  
204 implementation of standard drug concentration solutions administered using advanced  
205 safety pumps with inbuilt 'drug libraries' and default settings to facilitate selection of correct  
206 medication and dose.[11]

207 This study identified the need to improve current practice. Potential solutions include  
208 standardisation of morphine concentrations for N/PCA use and/or bulk manufacture of  
209 'ready-to-use' infusions in a quality-controlled environment, interventions to increase  
210 knowledge on the use of correct syringe size and overage in ampoules.

211

212 The study was conducted in a single paediatric NHS hospital and reflects the current  
213 practice there. The results may not be generalisable to all NHS paediatric hospitals,  
214 however, staff turnover between hospitals is large and thus there is no reason to believe that  
215 knowledge or practice elsewhere is significantly different. Not all staff who prepared  
216 morphine N/PCA infusions at this hospital participated in the focus groups and thus the full  
217 picture of practice cannot be guaranteed.

218

## 219 **CONCLUSIONS**

220 There is little standardisation of the techniques used to prepare N/PCA infusions for children,  
221 which raises concerns about the accuracy of current preparation practices. A particular issue  
222 was the lack of appreciation of the overage (excess volume) in morphine ampoules. The  
223 flaws identified in the current process should be addressed and a number of potential  
224 solutions were recommended.

225

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228

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233

#### 234 **Conflict of interest**

235 ANR was funded by the Health Foundation. Other authors declared no financial interests.

236

#### 237 **Ethical Approval**

238 This study was approved by the Research and Development (R&D) department at Guy's and  
239 St Thomas' NHS Foundation Trust (GSTT) and categorised as a non-Ethics study. The local  
240 NHS Research Ethics Committee confirmed that NHS ethics approval was not required.

241

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