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Behaviour and heart rate response in children and adolescents undergoing anesthesia with considerably altered (Covid-19-Related) safety precautions.

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Keypoints

1) There were considerable and abrupt changes to pediatric anesthetic practice during the early COVID-19 pandemic. These changes included prioritising the intravenous rather than inhalational induction technique, limiting parental presence at anesthetic induction and encouraging the use of pre-operative sedation irrespective of individual COVID-19 status.
2) The need for anesthetists to wear full personal protective equipment that obscured their faces had the potential to unsettle children. However, it is reassuring that in the acute perioperative situation our single-centre opportunistic study found little in the way of subjectively rated or objective physiology (heart rate) data to indicate that these children and adolescents were more unsettled compared to controls experiencing pediatric anesthesia without COVID-19 precautions.
3) We highlight that longer-term effects on healthcare-related behavior may nevertheless emerge in these children in relation to their unusual anesthetic experience. For this reason longer-term follow-up would be informative.

Abstract

Introduction

The COVID-19 pandemic imposed on us the requirement for fast and significant change to our anesthetic practice. Some anesthetic safety precautions (e.g. full personal protective equipment and restricting parent-attendance at anesthesia induction) had the potential to alter behavioral and physiological (anxiety-related) responses in children and adolescents undergoing surgery during this time, despite increased use of oral pre-sedation. We explored our unique dataset in order to provide preliminary and opportunistic data addressing this issue.

Methods

93 children and adolescents (1-16 years) underwent anesthesia for surgery at our large tertiary hospital during the first U.K. peak of the COVID-19 pandemic (approximately April 2020). All anesthetics were performed with COVID-19 safety precautions. A control group consisted of 91 children and adolescents undergoing anesthesia for surgery immediately before the peak-pandemic. Behavior was assessed by anesthetist-rating of cooperation and calmness of children and adolescents at anesthesia induction, and subsequently by recovery nurse subjective rating. Multiple heart rate values obtained for each child /

adolescent pre- and post-procedure were age-normalised and explored for incidence of tachycardia, which can relate to anxiety.

Results

Accounting for age group, behavior and heart rate values were comparable across groups. This was despite significant changes to anesthetic practice including reduced use of inhalational induction and therefore increased awake intravenous cannulation.

Conclusion

Behavior and heart rate data indicate some stability in children's and adolescent's acute response to anesthesia in the context of otherwise significant change to our practice. However, efforts should still be directed at assessing possible late-emerging behavioral and emotional responses to this altered-anesthesia experience, as this may yet influence how this cohort of children and adolescents engages with any future healthcare procedures.

Keywords

COVID-19, Pediatric Anesthesia, Sedation, Anxiety

Introduction

The COVID-19 pandemic required prompt changes to pediatric anesthetic practice, with major implications for how children and adolescents experienced surgery. Infection control measures were applied for all children and adolescents and included personal protective equipment (PPE) which obscured our faces, reduced parental presence at anesthetic induction, increased pre-operative sedation to limit crying and promotion of intravenous (with awake cannulation) over inhalational induction to minimise the risk of virus aerosolization. Such recommendations have been discussed in reviews.[1,2] While children and adolescents might respond with increased agitation and decreased co-operation at anesthetic-induction, it was also possible that increased sedation-use could buffer the potentially intimidating experience.[3]

Perioperative anxiety scales exist (e.g. Yale Pediatric Anxiety Scale [YPAS][4], Children's Perioperative Multidimensional Anxiety Scale [CPMAS][5], a visual analogue scale (VAS) [6]) and require variable staff training and co-ratings by parents. However, the research governance procedures required for their formal application were difficult to implement at short notice. There were nevertheless potentially important implications of an unusual, perhaps intimidating anesthesia experience during the COVID-19 pandemic for how these children and adolescents might respond to any future surgeries/procedures, a perspective consistent with '*planting-a-negative-seed*'. Indeed, a previous bad experience of healthcare is a significant predictor of children's future pre-operative and anesthesia-induction anxiety levels.[7-9] It was important therefore, to document the nature of acute (perioperative) COVID-19 time behavior in order that we may better understand any later emerging effects on response to future anesthetics.

Perhaps uniquely, we had both pre-existing, electronically charted, basic question-prompts for pediatric anesthetists about children's and adolescent's calmness and co-operation at anesthetic-induction and continuity in the staff providing these ratings during the pandemic. These data, alongside objectively recorded heart rates, provide some, albeit necessarily limited, insight into behavior and physiology in the acute pandemic-time perioperative setting compared to historical controls. As stated, they may help to serve as a basis for further research into how this cohort of children and adolescents respond to any subsequent healthcare intervention.

Methods

During our local peak of first-wave COVID-19 (31.03.20–12.05.20) 93 children (1-16 years) required surgery. Anesthetic practice, anesthetist-rated child behavior at anesthetic-induction and nurse-rated child behavior in this group was compared with that recorded in 91 children undergoing surgery in a randomly selected week pre-COVID-19 (02.01.20–09.01.20); importantly, this time-frame reflected a similar number of cases and enabled the inclusion of ratings from the same cohort of pediatric anesthetists / recovery nurses for both groups of children. As junior anesthetic staff had been largely redeployed to intensive care, the pediatric anesthetists

involved in these children's and adolescent's care were senior, most of whom had fully completed their training. Pediatric recovery room nurses were similarly experienced in caring for children and adolescents in the same dedicated pediatric recovery room environment. There was therefore continuity in the flow of the children's and adolescent's anesthetic experience: pre-operative sedation was administered on the pediatric admitting ward, awake intravenous cannulation followed by intravenous induction or inhalational induction followed by asleep intravenous cannulation were the main approaches, endotracheal tube 'extubation' occurred in theatres with subsequent full wake-up in the dedicated pediatric recovery room. Aspects of our practice that changed according to guidance during the early COVID-19 peak included the number of children having pre-operative sedation, the presence of parents at anesthetic induction, the number of children having intravenous induction of anesthesia and the necessity for staff to wear full PPE. With regards to recording behavior, our electronic notes system routinely prompts the anesthetist intra-operatively to make two judgements about the child's and adolescent's behavior during the preceding anesthetic-induction: 1. Patient Co-operation: Co-operative/Uncooperative. 2. Patient was: Calm/Anxious. During recovery, nurses' standard handover report typically included comments that the child was 'settled/comfortable' and/or 'no issues', partially settled: e.g. 'crying', 'agitated' at times, or generally 'sleepy'. Heart rate was recorded pre-operatively/on admission for day surgery, immediately prior to anesthetic-induction and in recovery. Heart rates for each child were compared to age-normative data, with values >/=90th percentile considered significantly raised.[10] Averaged data and statistical results are collated and presented in Table 1. Non-parametric statistics were applied (SPSS-v26-IBM-Corp.). A median-split of age resulted in two age groups (Table 1), with the younger group further subdivided in secondary analysis. We performed this secondary analysis due to the considerable rate of underlying behavioral development, particularly present in younger children. Parental presence at anesthetic-induction was routine practice pre-pandemic and is therefore assumed for the control-time group. In all cases oral midazolam was the sedation agent prescribed (age-calculated dose). Records indicated successful administration in all but 5 cases.

Results

Group data and statistical results are tabulated (Table 1) and reflect that overall, as expected, confirmed parental presence at induction (COVID-19 time 10.8%, 10/93; parents routinely invited to induction for controls) and the inhalational-induction technique (COVID-19 time 36.6%, 34/93 vs. CONTROL Time 63.7%, 58/91) decreased, with an increase in pre-operative sedation (COVID-19 time 50.5%, 47/93 vs. CONTROL time 6.6%, 6/91). Despite these changes, the majority of children and adolescents were subjectively rated as co-operative and calm at anesthetic induction and as 'settled' in the recovery room, similarly to pre-pandemic ratings (Table 1). Objectively-measured tachycardia rates were also comparable. Of note, no significant group differences for any behavioral rating or heart rate value emerged when the younger age-group was split (1-3 years (N=62) vs. 4-7 years (N=42).

Discussion

Pediatric surgery continued during the COVID-19 pandemic, but with the expected significant changes to our anesthetic practice. Firstly, our use of the inhalational induction technique decreased. This is preferred by many children and some adolescents who fear awake intravenous cannulation. Secondly, parental presence at anesthetic-induction was limited. Whilst this may not fully alleviate anesthetic-anxiety (particularly if parents themselves are highly anxious) it might nevertheless comfort children and adolescents when staff are wearing full PPE. However, it is reassuring that levels of co-operation at anesthetic-induction and/or agitation at induction or in the recovery room were comparable to our pre-COVID-19 experience as assessed by the same cohort of healthcare professionals. This was likely to be at least

Table 1	1-7 years			8-16 years		
	Control-Time	Covid-Time		Control-Time	Covid-Time	
N=	44	60		47	33	
Age (y)	3.5y (1-7)	3.0y (1-7)	P=.093	13.0y (8-16)	12.0y (8-16)	P=.063
Weight (Kg)	16.0 (8-41)	15.0 (8-35)	P=.093	50.0 (20-92)	44.0 (22-85)	P=.471
Gender	F 19 (43.2%) M 25 (56.8%)	F 16 (26.7%) M 44 (73.3%)	P=.078	F 24 (51.1%) M 23 (48.9%)	F 11 (33.3%) M 22 (66.7%)	P=.116
Surgery (i)	Abdo: 2 (4.5%) Ortho: 4 (9.1%) ENT: 14 (31.8%) Plastics: 3 (6.8%) Urol: 3 (6.8%) Neuro: 1 (2.3%) Ophthal: 3 (6.8%) Dental: 2 (4.5%) 'Scope': 6 (13.6%) 'Lines': 6 (13.6%)	Abdo: 6 (10.0%) Ortho: 4 (6.7%) ENT: 14 (23.3%) Plastics: 5 (8.3%) Urol: 3 (5.0%) Neuro: 7 (11.7%) Ophthal: 4 (6.7%) Dental: 0 'Scope': 3 (5.0%) 'Lines': 14 (23.3%)	-	Abdo: 3 (6.4%) Ortho: 10 (21.3%) ENT: 12 (25.5%) Plastics: 1 (2.1%) Urol: 4 (8.5%) Neuro: 3 (6.4%) Ophthal: 4 (8.5%) Dental: 5 (10.6%) 'Scope': 3 (6.4%) 'Lines': 2 (4.3%)	Abdo: 3 (9.1%) Ortho: 6 (18.2%) ENT: 2 (6.1%) Plastics: 4 (12.1%) Urol: 7 (21.2%) Neuro: 3 (9.1%) Ophthal: 0 Dental: 0 'Scope': 4 (12.1%) 'Lines': 4 (12.1%)	-
Expedited Surgery (ii)	12 (27.3%)	39 (65.0%)	Chi²14.5(1) P<.001	10 (21.3%)	25 (75.8%)	Chi² 23.4 (1) P<.001
'Out-of-Hours' Surgery (iii)	0	1 (1.7%)	P=.390	3 (6.4%)	4 (12.1%)	P=.439
Pre-operative Sedation Prescribed	N=44 3 (6.8%)	N=59 37 (62.7%)	Fisher's Exact P<.001	N=47 3 (6.4%)	N=33 10 (33.3%)	Fisher's Exact P=.006
Parents at Induction	-	7 (11.7%)	-	-	3 (9.1%) [unclear: 3]	-
Child Rated as Co-operative at Induction (iv)	N=19 15 (78.9%)	N=38 33 (86.8%)	Fisher's Exact P=.463	N=16 16 (100%)	N=14 13 (92.9%)	Fisher's Exact P=.467
Child Rated as Calm at Induction (iv)	N=18 14 (77.8%)	N=34 25 (73.5%)	Fisher's Exact P>.999	N=15 12 (80.0%)	N=14 13 (92.9%)	Fisher's Exact P=.598
Baseline Heart Rate >90thCentile (v)	N=39 3 (7.7%)	N=50 3 (6.0%)	Fisher's Exact P>.999	N=40 7 (17.5%)	N=30 8 (26.7%)	P=.355
Pre-Induction Heart Rate >90thCentile	N=36 11 (30.6%)	N=57 26 (45.6%)	P=.148	N=40 14 (35.0%)	N=32 16 (50.0%)	P=.200
Recovery Heart Rate >90thCentile	N=41 7 (17.1%)	N=50 15 (30.0%)	P=.152	N=43 9 (20.9%)	N=29 9 (31.0%)	P=.331
Anesthesia Prep. Time (vi) (Median; Mins)	N=28 16.0 (7-51)	N=47 13.0 (5-69)	P=.052	N=42 13.5 (5-54)	N=28 14.5 (5-56)	P=.746
Inhalational Induction	33 (75.0%)	29 (48.3%)	Chi² 7.5(1) P=.006	25 (53.2%)	5 (15.2%)	Chi² 11.9 (1) P=.001
Time in Recovery (Median; Mins)	N=41 52.0 (14-225)	N=57 63.0 (38-168)	U 745.5 Z-3.0, P=.002	N=43 50.0 (22-181)	N=33 65.0 (31-186)	U 502.0 Z-2.2, P=.030
Recovery Room Behavior (vii)	N=43 'Settled': 31 (72.1%) Partly-Settled: 11 (25.6%) Sleepy: 1 (2.3%)	N=58 'Settled': 47 (81.0%) Partly-Settled: 6 (10.3%) Sleepy: 5 (8.6%)	P=.070	N=47 'Settled': 43 (91.5%) Partly-Settled: 1 (2.1%) Sleepy: 3 (6.4%)	N=33 'Settled': 28 (84.8%) Partly-Settled: 2 (6.1%) Sleepy: 3 (9.1%)	P=.581

Table 1. Notes: Median (range) data divided by group and by age. Overall group sizes are given at the top, but subsequent sample sizes are given when lower due to missing and/or un-verifiable data. Group comparisons utilise the Chi-Square or Mann Whitney test. *(i) Abdo – abdominal cavity surgery, ENT – ear/nose/throat, Urol. – urology, Neuro – neurosurgery, Ophthal. – ophthalmology, Lines – e.g. PICC, Hickman lines, 'Scope' – endoscopy / colonoscopy / bronchoscopy. (ii) Expedited surgery includes any surgery that is not deemed to be elective. It covers a range from 'fast-tracked' to emergency. (iii) Out-of-hours surgery includes any surgery not carried out between 8am to 7pm, Monday to Friday, and therefore covered by an on-call team of anesthetists. (iv) Ratings made by anesthetists during the procedure on the anesthetic charting system. (v) Heart rates were recorded automatically on our patient electronic notes system. Each heart rate (beats per minute) was compared to published age-normative data[10]. Heart rate values are rated as above or below the 90th centile for each child, thus representing degree of tachycardia present at each stage. (vi) Anesthesia preparation time: duration (mins) between arrival in theatre and 'anesthesia ready'. (vii) Recovery room nurse rating according to their standard documentation format, noting if a child appears 'settled', partially settled (e.g. upset, cross, pulling at their cannula or oxygen mask at times), or mostly sleeping.*

partly due to an increase in the use of pre-operative sedation. It is important to document this profile of results in the context of the profound and abrupt change to anesthetic practice resulting from the COVID-19 pandemic. These opportunistic data provide some indication of children's and adolescent's apparent tolerance of the changes in pediatric anesthetic practice, but previous data[7-9] would suggest that they are insufficient to rule out a subsequent negative response to future healthcare interactions. We simply suggest that should 'pandemic-anesthesia' children and adolescents find the prospect of future surgeries/procedures more upsetting than expected, this may be for multifactorial reasons *not limited to* having had an unusual anesthesia-induction experience. These reasons could include perhaps the more general hospital environment during the pandemic (e.g. social isolation procedures, everyone in face masks and increased stress-level of staff) and/or sedation-induced confusion. We note also that children and adolescents may have had greater pre-existing level of anxiety related to their home environment or lack of school attendance at the time of their surgery and that this may have muted any additional effect of anesthesia-related anxiety. Indeed a spectrum of mental health issues may affect children and adolescents generally due to the social impact of COVID-19 and requires longer-term follow up[11]. Any longer-term contribution of a superimposed anesthesia and surgery experience during this time also remains to be seen. The possible outcomes include no additional effect of the altered anesthesia experience on baseline behavior / emotion in these children and adolescents when measured acutely (as suggested herein) or in the longer-term, or later-emerging negative perception of anesthesia, perhaps presenting with the trigger of a subsequent anesthesia experience.

The circumstances of the COVID-19 pandemic largely prevented application of "gold-standard"[4] pediatric perioperative anxiety-scales. Undoubtedly should institutional review committee approval have been gained for the wide application of these scales within a short timeframe, these data would be very informative indeed. These scales were of course validated on pre-pandemic children experiencing anesthesia without pandemic-induced changes to their home life, without strict safety precautions in the hospital, and likely with parental-presence at induction, thus facilitating the parental-rating part also. Our two simple items relating to behavior at anesthetic-induction ('co-operative'/'calm') resonate with *but cannot replace* the VAS[6], and the modified-YPAS[4] descriptions, e.g. '[…]actively trying to get away / screaming "no" / pushing others away[…]'), '[…]crying or may be screaming "no" / distressed, crying, extreme upset[…]'.

Behavioral ratings were not consistently available for all children. The completion of these items for all children and adolescents was not prioritised at this time of fast-adaptation in healthcare. In addition, prompting staff might have influenced ratings through their increased awareness of this audit. Our objective heart rate data are relevant in this respect, with comparable tachycardia-rates across groups providing further support for behavioral stability; albeit the contribution of situational anxiety is not distinguished from possible heart rate variation due to illness severity and/or administered medications. Inclusion of sicker children and adolescents and/or increased sedation-use, may also partly explain prolonged recovery room times (Table 1).

We are cautiously relieved about the lack of change in our behavioral and heart rate data in the acute perioperative setting, but acknowledge that further and longer-term studies may provide less reassurance. Based on the literature[7-9], we recommend vigilance as late-emerging effects of this unusual anesthetic experience may yet emerge, perhaps in the context of future response to anesthetics/procedures, e.g. greater distress exhibited than anticipated. Not least, facilitating an un-sedated (and thus remembered) positive first anesthetic experience could underlie many children's and adolescent's subsequent engagement with healthcare ('*planting-a-positive-seed'*) and this opportunity is perhaps now lost for some

of this cohort. We thus highlight this situation of changes to COVID-19 pandemic-time anesthesia practice to bring wider recognition that greater pre-procedure preparation and reassurance may be required in the future despite the resilience these children and adolescents apparently demonstrated at the time.

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