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Changes in sensory processing after anesthesia in toddlers

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What is already known

Postoperative behavioral changes are very common after anesthesia in children, especially in very young children

What this article adds

In toddlers sensory processing skills changed after anesthesia

Abstract

Background: Pediatric anesthesia and surgery may influence sensory processing and consequently postoperative adjustment and behavior in toddlers. So far, this is an unexplored field of research.

Aims: 1. test pre- to postoperative changes in sensory processing after pediatric anesthesia using the Infant/Toddler-Sensory Profile for 7-36 months ($ITSP_{7-36}$); 2. identify possible predictors of these changes.

Methods: This prospective cohort study included 70 healthy boys (ASA I & II), aged 18-30 months, who underwent circumcision for religious reasons**.** Boys with prior surgery and known developmental delay were excluded.

Changes in sensory processing from the admission to day 14 postoperatively were assessed using the $ITSP_{7-36}$, which was completed by the accompanying parent. Predictor variables used were: 1. the children's preoperative emotional/behavioral problems; 2. the children's state anxiety at induction; 3. postoperative emergence delirium; 4. postoperative pain at home. All children received standardized anesthesia and pain management in hospital and at home.

Results: For 45 boys, assessments were completed at both time points. Significant changes in sensory processing (mean $ITSP_{7-36}$ scores) were found on quadrants for low registration (47.5 to 49.8; $P = .015$), sensory sensitivity (45.2 to 48.0; $P = .011$), sensation avoiding (48.2 to 51.3; $P = .010$) and low threshold (93.4 to 99.4; $P = .007$) and on sections for auditory processing (39.3 to 43.3; $P = .000$) and tactile processing (53.9 to 58.4; $P = .002$). Higher scores on emotional/behavioral problems (Total problems) predicted changes on sensory processing (for low registration, sensory sensitivity, low threshold and tactile processing).

Conclusions:

Sensory processing skills of toddlers changed after anesthesia. Children with higher scores on emotional/behavioral problems (Total problems) are more vulnerable to these changes.

Keywords: toddlers, pediatric anesthesia, sensory processing, postoperative behavior

Introduction

Postoperative behavioral changes in preschool children are very common after anesthesia and surgery, with incidence rates ranging from 80.4% at day one postoperatively, to 32% four weeks after discharge and still 16% after three months (1-3). The psychological impact of these changes cannot be ignored as in a minority of cases they may last even longer, from several months (1) up to even more than a year (4). Furthermore there are some indications that young children are actually more vulnerable to such changes than older children (1, 4, 5).

Research has shown a relationship between children's perioperative anxiety, emergence delirium and postoperative pain on the one hand and postoperative behavioral changes on the other hand (1, 3, 6). It may be that changes in sensory processing contribute to postoperative behavioral changes as well. Sensory processing encompasses the way toddlers perceive, modulate, integrate and self-regulate sensory information, and also how this sensory processing influences the toddlers arousal, attention, affect and action. In this way, a change in sensory processing might influence postoperative behavior changes, since it has an impact on the child's ability to participate in play, to learn and to show adaptive social functioning at home. However, to the best of our knowledge, until now no studies have investigated whether changes in sensory processing do actually occur after pediatric surgery.

Furthermore, we postulate that several variables which have been demonstrated to predict postoperative behavioral changes, may also influence postoperative sensory processing in young children. Previous studies showed that higher scores on preoperative emotional/behavioral problems (such as anxiety, depressive symptoms) are associated with higher levels of children's anxiety at induction (7, 8). We hypothesize that children's pre- and perioperative emotional/behavioral problems (e.g. anxiety), but also emergence delirium (ED) and pain during the perioperative period will change the child's sensory processing.

In this field of research, hardly any studies have focused on sensory processing for the distinctive age-range of toddlerhood. This is the first study using the Infant/Toddler Sensory Profile-NL ($ITSP_{7-36}$) to identify changes in sensory processing after pediatric anesthesia and as such the influence on postoperative behavior. The $ITSP_{7-36}$ is a well validated questionnaire for young children. It assesses sensory stimulus threshold changes (see Methods) (9) and specifically targets the toddler age group. Therefore this study aims to:

I. Test pre- to postoperative changes in sensory processing, assessed by the $ITSP_{7\text{-}36}$ up to two weeks after a surgical day care procedure under anesthesia in children aged between 18 – 30 months.

II. Test whether these changes in sensory processing can be predicted by: 1. the children's preoperative emotional/behavioral problems; 2. the children's state anxiety at induction; 3. postoperative emergence delirium (ED); 4. postoperative pain at home.

Methods

This prospective observational cohort study was conducted at the Queen Paola Children's Hospital in Antwerp, Belgium between April 2012 and April 2014, with approval from the Institutional Review Board (B009; OG031 E.C. approval N° 3952). It was part of a larger trial (www.trialregister.nl / NTR 3306), and was conducted in accordance with the Declaration of Helsinki and the STROBE statement for observational studies.

Inclusion criteria: boys aged between 18-30 months, undergoing circumcision because of religious reasons in day care hospital; written informed consent; an American Society of Anesthesiologists (ASA) physical status I-II; no premedication; parents with a satisfactory written understanding of Dutch language; one accompanying parent during induction.

Exclusion criteria: children with a known developmental delay, prior surgery under anesthesia.

Demographical/medical data: were collected on the day of admission by a research nurse. Socioeconomic status (SES) was categorized, based on parental highest educational level into: 1. no education, elementary school; 2. secondary school; 3. higher education or university.

Anesthesia procedure: all parents and children received standardized preoperative information. The anesthesia procedure was also standardized. In line with standard practice in our hospital, all inductions were performed by inhalation of sevoflurane 8 vol.% in 50% oxygen without nitrous oxide and were maintained with sevoflurane 2.5 vol.%. Intraoperative pain management included: 1. a penile block with chirocaïne 2.5%; 2. opioids (pethidine); 3. a non-steroidal anti-inflammatory drug (NSAID). 4. ondansetron (0.1 mg /kg) for post-operative nausea and vomiting (PONV) management. For in-hospital postoperative pain management all children received paracetamol IV (20 mg. kg^{-1}). At the end of surgery the inhalation agent was discontinued and the children were transferred to the Post Anesthesia Care Unit (PACU) and afterwards again to the ward were they stayed at least for 2 hours before discharge.

For postoperative pain management at home written instructions were given, it consisted of oral administration of acetaminophen 60mg/kg divided in 4 doses for 3 days. Prescribed pain medication adherence by the parents was noted at day 1.

Assessment tools and assessment moments (fig. 1)

Main Outcome

The ITSP$_{7-36}$ (10) was used to assess sensory processing skills of babies and toddlers between 7 and 36 months old. It consists of 48 structured questions (response categories: 1 = almost always to 5 = almost never) and 2 open questions, resulting in a sensory processing summary covering 5 processing sections: 1. auditory (reaction to sound, noise, voices); 2. visual (reaction to anything that can be seen); 3. tactile (reaction to touching of the skin); 4. vestibular (reaction to movement); 5. oral sensory (reaction to touch, taste and smell).

In addition 4 quadrant scores can be calculated: 1. weak registration (consciousness/ awareness to different sensory stimuli); 2. sensation seeking (seeking more intense sensory experiences); 3. sensory sensitivity (ability to notice sensory stimuli); 4. sensory avoiding (to counteract/avoid or control sensory stimuli). Finally a low threshold score is derived from the summation of quadrant 3 and 4. Quadrants are separated but related concepts.

The ITPS$_{7-36}$ was completed by the parents preoperatively at admission [T1] and postoperatively at day 14 [T14] (Fig. 1).

Predictor variables

The Child Behavior Checklist 1½-5 (CBCL/1½-5) (11), an internationally validated parent-report questionnaire, was used to assess preoperative emotional/behavioral problems during the past 2 months. It was completed by the accompanying parent prior to surgery at [T1] (Fig. 1). It consists of 100 problem items (response-categories: 1. not true; 2. somewhat or sometimes true; 3. very true or often true). Summary scores on Internalizing problems (Emotionally Reactive, Anxious/Depressed, Somatic Complaints, Withdrawn), Externalizing problems (Attention Problems and Aggressive Behavior), Sleep Problems and a Total Problem score were computed. Higher scores indicate more problems. Good validity and reliability for the Dutch version have been reported (12).

A Visual Analogue Scale (VAS$_{anxiety\text{-}induction}$) was used to assess the child's anxiety at induction by the attending pediatric anesthesiologist. This VAS$_{anxiety}$ scale consisted of a 100 mm horizontal line, with the two ends representing the opposite, extreme limits of the child's anxiety (i.e., 'absolutely no anxiety' and 'extreme anxiety'). The VAS$_{anxiety}$ has been used to measure anxiety in preoperative settings (13).

Emergence delirium (ED) was assessed postoperatively using the Watcha scale, which consists of 4 items: 1. calm; 2. crying, but consolable; 3. crying, not consolable; 4. agitated, kicking with arms and legs. A Watcha sum score was calculated, based on the scores at 5, 10, 15, and 20 minutes after awakening and a mean sum > 2 was considered as ED present. The scale is very easy to use and has a high overall sensitivity and specificity (14).

The Face, Legs, Activity, Cry, Consolability (FLACC) (15) was used to measure pain intensity, based on 5 criteria: facial expression, leg movement, activity, crying and consolability. Each criterion was assigned a score of 0, 1, or 2, resulting in a total score ranging from 0 to 10. The FLACC was filled in 1 and 2 hours after surgery, on the ward by an independent nurse. The FLACC has a good interrater reliability and validity for use in the postoperative phase (15). Mean sum scores were calculated and further dichotomized into 2 groups (non to mild pain *vs.* moderate to severe pain) using cut-off values of respectively ≥ 3 on the FLACC.

To assess the child's postoperative pain a Numerical Rating Scale (NRS) (16) was used. At day 1 after discharge a telephone call was made by the research nurse to register parental rating of the child's pain (score-range: 0-10; item: how much pain did your child experience on average after surgery?). At day 14, parental pain rating was repeated by a new telephone call (score-range: 0-10; asking how much pain did your child experience on average during the past 14 days). NRS scores < 4 can be considered as no or mild pain, whereas scores ≥ 4 indicate moderate to serious pain (17).

Statistical analysis

Power calculation showed that, based on a difference (effect size 0.5) on the low threshold score of the $ITSP_{7\text{-}36}$, a total sample size of 44 would suffice to answer our research question (GPOWER version 3.1.2) with a power of 0.90 and an alpha of < 0.05.

Demographic data and scores regarding children's and parents questionnaires were displayed as means ± standard deviations (continuous data), as percentages (categorical data) or as median with IQR. Skewness and kurtosis were used to check for normality.

Aim 1: paired T-tests tested differences in $ITSP_{7\text{-}36}$ scores between [T1] and [T14] on: 1. sensory processing section scores; 2. quadrant scores; 3. low threshold score.

Aim 2: univariate relationships between changes in sensory processing over time on the $ITSP_{7\text{-}36}$ (restricted to those ITSP scales that showed statistically significant differences between pre- and postoperative scores) and the predictor variables (preoperative emotional/behavioral problems; child anxiety at induction; postoperative ED and postoperative pain at home) were tested, using Pearson correlation coefficients.

Next, multivariable linear regression (forced entry method) was used to analyze whether the changes in sensory processing (again restricted to those ITSP scales that changed significantly over time) could be explained by the predictor variables mentioned above. To avoid multicollinearity issues (assessed by variance inflation factors), predictor variables that correlated highly with other predictors were excluded from the regression analyses. The *β's* in the standardized regression coefficients express the strength of each predictor in the regression equation. Linearity, homoscedasticity, independence and normality of residuals were checked.

All analyses were performed with IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp. P-values of < 0.05 were considered statistically significant.

Results

From the 116 children approached, 70 participated (response rate 60 %, Figure 2). The children's mean age was 22.8 months (± 4.5 SD) (Table I). For 25 (35.7%) children, data were missing at T14, because telephone contact was not possible or parents did not complete the $ITSP_{7\text{-}36}$, neither after a second telephone reminder. Thus for 45 children both pre- and postoperative data (T1 and T14) were completed.

For the 70 participants Watcha scores showed that 22.7 % (n = 15; 4 missing values) was categorized as having emergence delirium (ED) during the first 20 minutes after awakening (Table I).

Postoperative mean pain scores with the FLACC scale (n = 70) revealed 1 child with a score > 3. As assessed by the parental NRS, the postoperative pain at home of 49.3% (n = 35) of the children was considered moderate to serious at day 1. At day 14, a similar proportion of the parents (n = 22, 48.9%) parents reported that the overall pain experienced the past 14 days by their child was moderate to serious. Prescribed pain medication at day 1 at home was given conform instructions by 57.1% (n = 40) of parents.

The parent who accompanied the child during induction of anesthesia was the father in almost two third (62.9%) of the cases.

Pre- postoperative changes sensory processing

Paired T-tests showed statistically significant differences between $ITSP_{7\text{-}36}$ mean scores on T1 and T14 on the sections auditory and tactile processing, indicating that children postoperatively have a significantly sharper, more sensitive auditory and tactile information process (Table II). On the 'visual processing' and 'vestibular processing' sections of the $ITSP_{7\text{-}36}$, the children's scores increased slightly over time, but these changes were too small to be statistically significant. Except for the sensation seeking quadrant, all quadrant scores increased significantly over time.

Prediction of changes in sensory processing

Results of the univariate analyses showed significant associations between the CBCL Total problems, Internalizing problems and changes in sensory processing over time (Pearson's r in the range of 0.29 to 0.43). This holds for all ITSP sensory processing sections and all quadrant grids, except for the relationship between Internalizing problems and auditory processing (Table III). Regarding CBCL

Externalizing problems, weak positive correlations with changes in ITSP scores were found, as shown by the Pearson's coefficients of 0.19 to 0.28 (none of them reaching statistical significance).

In the multivariate regression analysis analyses, the NRS pain score at day 1, the CBCL Internalizing problems score, and the CBCL Externalizing problems score were left out, for reasons of multicollinearity. So, the following predictor variables were included: 1) emotional/behavioral problems (total score); 2) anxiety at induction, 3) postoperative ED and 4) postoperative assessment of pain during the past 14 days. As shown in Table 4, the analyses revealed that the majority of changes over time on the ITSP were related to higher scores on preoperative Total emotional/behavioral problem scores. This was the case for tactile processing and 3 out of 4 the quadrant grids (i.e. low registration, sensory sensitivity and low threshold). Postoperative pain and anxiety at induction generally did not make a statistically significant contribution to explaining the changes in sensory processing. This holds even stronger to emergence delirium, which was found to be the weakest predictor of changes in sensory processing.

Discussion

The present study found evidence for significant pre- to postoperative changes in sensory processing of children undergoing circumcision. Although, on average, the children's scores were in the normal range on all scales both before and after surgery, we found significant changes in auditory and tactile processing 2 weeks after surgery. Postoperatively children showed less distinct behaviors when reacting to auditory and tactile stimuli. Preoperative Total emotional/behavioral problems (especially Internalizing problems) significantly predicted pre- to postoperative changes in sensory processing as to tactile processing, low registration, sensory sensitivity and low threshold.

The increased scores on low registration, sensory sensitivity, sensation avoiding, and low threshold indicate that, compared to their pre-operative situation, in some situations the children *miss less* or detect more *information* (i.e. show less behaviors associated with 'low registration': e.g. parents do not have to touch the child to get attention and parents do not have to talk loud to get attention). In other situations however, they *detect less* (i.e. show less behaviors reflecting 'sensory sensitivity', e.g. do not startle from noise), and are *less bothered by input* (i.e. show less 'sensation avoiding', e.g. the child does not resist to cuddling). These divergent findings can be explained by the fact that the different quadrants of the ITSP encompass behaviours to different sensory stimuli. In other words; generally speaking, children may react strongly (by avoiding) to auditory stimuli, while they react less strongly to motion stimuli. And children may react differently in different situations to the same stimuli.

Overall, our findings on the pre- to postoperative changes in sensory processing show that postoperatively after circumcision, in most situations these children react less strong to sensory input When children react less pronounced to sensory stimuli, their behaviour could be interpreted as withdrawn or passive. However, these changes, reflected by higher scores on the ITSP, do not necessarily imply more problematic behavior. However, when children are less conscious or less aware of sensory stimuli, they sometimes are less able to notice information. This could be the case so for children in this study, since quadrant scores on sensation sensitivity, sensation avoiding, and the low threshold score are higher in the post-operative period. This could give rise to under-responsive behavior which could be explained through habituation after the surgical experience. These are important findings, as a change in sensory processing can influence the child's ability to participate in play, learning and social opportunities at home and could explain observed changes in behavior.

We found that the changes in the ITSP scores were associated with preexisting emotional/behavioral problems. This could be explained by the fact that children with more Total emotional/behavioral problems (especially Internalizing; emotionally reactive, anxious/depressed, somatic complaints, withdrawn) have more behavior inhibition (18). These children tend to be more calm, withdrawn and in general react less strong to different experiences. This is consistent with the findings of Fortier *et al* (19), who reported that individual child emotional and behavioral problems as assessed with the CBCL were predictive for changes in postoperative behavior.

Although pain has been identified as a strong risk factor of postoperative problematic behavior (3, 5), in this study no clear associations was found between pain and pre- to postoperative changes in sensory processing. The child pain scores in hospital were very low, this in contrast to parental pain assessments of their child at home. Almost 50% of children experienced moderate to significant pain at day 1 postoperatively. Although 50% of children experienced significant pain at home, 40% of parents did not follow the prescribed pain management. These results regarding postoperative pain at home and prescribed pain medication adherence are in line with previous research (20). Moreover, the fact that the surgery had a religious character, which might contribute to a different parental attitude to pain medication. The religious character of the surgery might also explain the relative high attendance of fathers as accompanying parents.

Other risk factors reported in the literature for postoperative behavioral changes are child's state anxiety and ED (4, 6). In this study a pattern in this direction could be found, that the child's anxiety at induction seemed to be associated with changes in sensory processing. But overall, however, the regression coefficients did not reach the level of statistical significance. This may be partly explained by the fact that measuring state anxiety at induction in very young children is very difficult, since no validated observational instruments exists for this purpose.

ED seemed to be the weakest predictor of changes in sensory processing. Assessing ED or even behavior at awakening of anesthesia certainly in very young children is challenging. This might explain why no associations were found between ED and sensory processing changes in our study.

Strengths and limitations

Strengths: this study is innovative since it is the first investigating: a) pre-to postoperative changes in sensory processing changes in a *homogeneous* group of *toddler*s, using a well validated questionnaire:

the ITSP and b) identifying preoperative children's Total emotional/behavioral problems (especially the Internalizing problems) as a significant predictor, using the internationally well-known CBCL.

Limitations

This was single center study. To what extent selection bias may have influenced our results is unknown. The children underwent circumcision due to religious reasons, which may also have affected our results. Furthermore, the same parents completed both CBCL and $ITSP_{6-36}$, this may have affected the associations (this phenomenon, that a same respondent completes several measures is known as "shared method "variance) (21).

For future research we recommend to assess changes in sensory processing also after other pediatric procedures, using a multi-informant approach (both fathers, mothers as respondents).

Conclusions

Our findings showed that following surgery, toddlers (18-30 months) showed changes in sensory processing. More specifically, they react less sensitive to sensory input, suggesting higher thresholds and more habituation. Future research should address the impact of these changes on reported postoperative behavioral changes. Preoperative emotional/behavioral problems predicted pre-to-postoperative changes in sensory processing. Anesthesiologists should be aware that children with current emotional/behavioral problems are more vulnerable to postoperative changes in sensory processing.

Disclosures

1. Ethical approval: Approval from the ZNA Middelheim Institutional Review Board (B009; OG031 E.C. approval N° 3952), Lindendreef 1, 2020 Antwerp, Belgium.
2. Funding: This study was funded by institutional means.
3. Conflict of interest: The authors declare no conflicts of interest.

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Table I

Demographic and psychological assessment of the children and accompanying parent.

	Children with complete assessments at 2 time points (n = 45)	Total (n = 70)
Children		
Age (months)	23 ± 4.0	22.8 ± 4.5
Weight	12.7 ± 2.3	12.8 ± 2.3
[a]ASA I	42 (93.3%)	63 (90%)
Born prematurely	4 (8.9%)	4 (5.7%)
Number of siblings ≥ 1	37 (82.2%)	58 (82.6%)
Prior hospitalizations	12 (26.7%)	19 (26.1%)
Nationality		
Belgium	37 (82.2%)	57 (81.4%)
other	8 (17.8%)	13 (18.6%)
[b]CBCL		
Internalizing problems	8.8 ± 7.3	8.7 ± 6.8
Externalizing problems	12.0 ± 6.4	11.6 ± 6.6
Total problems	31.9 ± 20.3	31.8 ± 18.9
[c]Anxiety at induction ($VAS_{anxiety\text{-}induction}$)	60.5 ± 29.2	65.5 ± 27.6
[d]Emergence delirium (Watcha score > 2) (4 missing values)	10 (23.8%)	15 (22.7%)
[e]Postoperative pain (FLACC score)	0 (0 – 0)	0 (0 – 0)
[f]Pain at home (NRS)		
postoperative day 1	4 (0 – 6)	3 (2 – 6)
postoperative day 14	3 (0 – 7)	
Prescribed pain medication adherence	23 (51.1%)	40 (57.1%)
Parents		
Gender (% male)		
[g]Highest educational level 1	11 (24.4%)	17 (24.3%)
2	28 (62.2%)	42 (60%)
3	6 (13.3%)	11 (15.7%)

Data are expressed as mean ± SD or as number (%) or as median with IQR. [a]ASA, American Society of Anesthesiologists; [b]CBCL, Child Behavior Checklist/1,5-5 (Internalizing, Externalizing and Total Problems); [c]Child Anxiety at induction: $VAS_{anxiety\text{-}induction}$, Visual Analogue scale anxiety; [d]Emergence delirium – total Watcha score was obtained by summing the scores at 5 min, 10 min, 15 min and 20 min after awakening; [e] Postoperative pain: FLACC = Face, Legs, Activity, Cry, Consolability scale, sum score (1 hour + 2 hour) ; [f]Pain at home: NRS = Numeric Rating scale at postoperative day 1 and day 14; Highest educational level:1. no education, elementary school; 2. secondary school; 3. higher education or university.

Table II

Pre to postoperative changes in mean scores on the Infant/Toddler sensory profile 6 – 36 months

	T1 (n = 45)	**T 14** (n =45)	mean DIFF	*P* value	ES
Sensory processing section					
Auditory processing	39.3 [37.8, 40.8]	43.3 [42.0, 44.7]	4.0 [2.5, 5.7]	.000**	0.77
Visual processing	22.0 [20.8, 23.3]	22.4 [21.3, 23.6]	.36 [.9, 1.6]	.57	
Tactile processing	53.9 [51.3, 56.7]	58.4 [56.0, 60.7]	4.5 [1.8, 7.0]	.002*	0.50
Vestibular processing	20.1 [19.1, 21.2]	20.3 [19.2, 21.4]	.2 [.8, 1.1]	.75	
Oral sensory processing	29.2 [27.9, 30.5]	28.0 [26.8, 29.3]	1.2 [2.8, .5]	.18	
Quadrant Grid					
Quadrant 1 - Low registration	47.5 [45.6, 49.5]	49.8 [48.7, 50.9]	2.3 [.5, 4.1]	.015*	0.38
Quadrant 2 - Sensation seeking	35.9 [33.5, 38.5]	36.2 [33.8, 38.6]	.3 [-2.1, 2.7]	.82	
Quadrant 3 - Sensory sensitivity	45.2 [43.1, 47.4]	48.0 [46.3, 49.8]	2.8 [.7, 4,9]	.011*	0.40
Quadrant 4 – Sensation avoiding	48.2 [46.0, 50.4]	51.3 [49.1, 53.5]	3.1 [.8, 5.5]	.010*	0.40
Low Threshold	93.4 [89.4, 97.5]	99.4 [95.6, 103.1]	6.0 [1.7, 10.1]	.007*	0.42
(combined quadrant 3+4 score)					

Data are expressed as mean (95% CI); T1 = baseline measure; T14 = measure at day 14 postoperative; mean DIFF: mean difference. Paired T-tests between quadrant scores at T1 and T14 and sensory processing section at T1 and T14. *P < 0.05; **P ≤0.01 as determined with a paired T-test. ES: effect size.

Table III

Prediction of pre- to postoperative changes on quadrant and sensory processing sections of the Infant Toddler/Sensory Profile between T1 and T14 - univariate associations

Pearson correlation matrix

	1.	**2.**	**3.**	**4.**	**5.**	**6.**	**7.**	**8.**	**9.**	**10.**	**11.**	**12.**	**13.**	**14.**
[a]ΔQ. 1	1													
[b]ΔQ. 3	.41**	1												
[c]ΔQ. 4	.46**	.77**	1											
[d]ΔQ.LT	.46**	.93**	.95**	1										
[e]ΔaudP	.52**	.70**	.60**	.69**	1									
[f]ΔtactP	.46**	.82**	.83**	.88**	.62**	1								
[g]Internalizing problems	.33*	43**	.30*	.38**	.21	.37*	1							
[g]Externalizing problems	.28	.25	.19	.23	.24	.28	.64**	1						
[g]Total problems	.39**	.43**	.30*	.38**	.30*	.38*	.92**	.85**	1					
[h]$VAS_{anxiety-induction}$	-.02	.23	.16	.21	.06	.24	.27	.07	.17	1				
[i]ED – total Watcha score	-.14	.01	-.13	-.07	-.05	-.02	.21	.14	.16	.24	1			
[j]NRS postoperative day 1	.06	.09	.00	.05	.09	.11	.19	.32*	.30*	.01	.04	1		
[j]NRS postoperative day 14	-.23	.11	-.06	.02	-.04	-.04	.18	.27	.19	.17	.43**	.43**	1	

Pearson correlation coefficients: *P<0.05; **P≤0.01 (2-tailed). **Dependent variables from the Infant Toddler/sensory Profile (ITSP)** : [a]ΔQ. 1 = Difference quadrant 1 = [quadrant 1 T14] – [quadrant 1 T1]; [b]ΔQ. 3 = Difference quadrant 3 = [quadrant 3 T14] – [quadrant 3 T1]; [c]ΔQ. 4 = Difference quadrant 4 = [quadrant 4 T14] – [quadrant 4 T1]; [d]ΔQ.LT = Difference low threshold = [quadrant 3+4 T14] – [quadrant 4 T14]; [e]Δuadp = Difference Auditory processing = [Auditory processing T14] – [Auditory processing T1]; [f]Δtactp = Difference Tactile processing = [Tactile processing T14] – [Tactile processing T1].
Independent variables: [g]Child Behavior Checklist/1,5-5 as assessed by the accompanying mother or father, Internalizing, Externalizing and Total problems; [h]$VAS_{anxiety-induction}$: Child anxiety at induction = Visual Analogue Scale anxiety at induction; [i]ED, emergence delirium - Watcha total score was obtained by summing the scores at 5 min, 10 min, 15 min and 20 min after awakening; [j]NRS = Numeric Rating scale at postoperative day 1 and day 14.

Table IV

Final results of the multivariate regression models

	B	β	CI 95%	*P*-value	R^2	*P*-value
Sensory processing						
Auditory processing (ΔaudP)						
CBCL – total problems	.064	.273	[-0.014, 0.143]	.103	.125	.309
Anxiety at induction ($VAS_{anesthesiologist}$)	.022	.138	[-0.032, 0.077]	.413		
ED (total Watcha score)	.031	.021	[-0.493, .555]	.905		
Postoperative pain (NRS day 14)	-.371	.204	[-1.020, 0.279]	.255		
Tactile processing (ΔtactP)						
CBCL – total problems	.120	.299	[-0.003, 0.243]	.055	.253	.033*
Anxiety at induction ($VAS_{anesthesiologist}$)	.088	.320	[0.002, 0.174]	.044		
ED (total Watcha score)	.014	.006	[-0.809, 0.838]	.972		
Postoperative pain (NRS day 14)	-.852	-.276	[-1.873, 0.169]	.099		
Quadrant Grid						
Quadrant 1 – Low registration (ΔQ. 1)						
CBCL – Total problems	.124	.417	[0.033, 0.215]	.009	.251	.034*
Anxiety at induction ($VAS_{anesthesiologist}$)	.004	.019	[-0.060, 0.068]	.902		
ED (total Watcha scores)	-.127	-.070	[-0.739, 0.484]	.675		
Postoperative pain (NRS day 14)	-.719	-.314	[-1.478, 0.039]	.062		
Quadrant 3 – Sensory sensitivity (ΔQ. 3)						
CBCL – Total problems	.114	.371	[0.020,0.209]	.019	.247	.037*
Anxiety at induction ($VAS_{anesthesiologist}$)	.059	.278	[-0.007, 0.125]	.080		
ED (total Watcha scores)	-.037	-.019	[-0.671, 0.598]	.908		
Postoperative pain (NRS day 14)	-.289	-.122	[-1.076, 0.498]	.461		
Quadrant 4 – Sensation avoiding (ΔQ. 4)						
CBCL – Total problems	.094	.262	[-0.20, 0.208]	.103	.194	.100
Anxiety at induction ($VAS_{anesthesiologist}$)	.064	.260	[-0.016, 0.144]	.112		
ED (total Watcha scores)	-.201	-.091	[-0.966, 0.563]	.597		
Postoperative pain (NRS day 14)	-.684	-.247	[-1.632, 0.265]	.152		
Quadrant – Low Threshold (ΔQ.LT)						
CBCL – Total problems	.209	.338	[0.018, 0.399]	.033	.241	.042*
Anxiety at induction ($VAS_{anesthesiologist}$)	.123	.290	[-0.010, 0.256]	.069		
ED (total Watcha scores)	-.238	-.062	[-1.514, 1.039]	.708		
Postoperative pain (NRS day 14	-.973	-.205	[-2.557, 0.610]	.220		

Significance different models, *P<0.05. **P≤0.01; **Independent variables**: 1.CBCL – preoperative Total problems, Child Behavior Checklist/1,5-5; 2. The child's anxiety at induction with a Visual Analogue Scale - $VAS_{anesthesiologist}$; 3. ED: emergence delirium as assessed with the Watcha scale (total Watcha score); 4. Postoperative pain scores by a Numerical Rating Scale (NRS) at day 14 NRS-scores).
Dependent variables from the Infant Toddler/sensory Profile (ITSP) : ΔQ. 1 = Difference quadrant 1 = [quadrant 1 T14] – [quadrant 1 T1]; ΔQ. 3 = Difference quadrant 3 = [quadrant 3 T14] – [quadrant 3 T1]; ΔQ. 4 = Difference quadrant 4 = [quadrant 4 T14] – [quadrant 4 T1]; ΔQ.LT = Difference low threshold = [quadrant 3+4 T14] – [quadrant 4 T14]; Δuadp = Difference Auditory processing = [Auditory processing T14] – [Auditory processing T1]; Δtactp = Difference Tactile processing = [Tactile processing T14] – [Tactile processing T1].

Figure 1

Flowchart diagram of different assessment

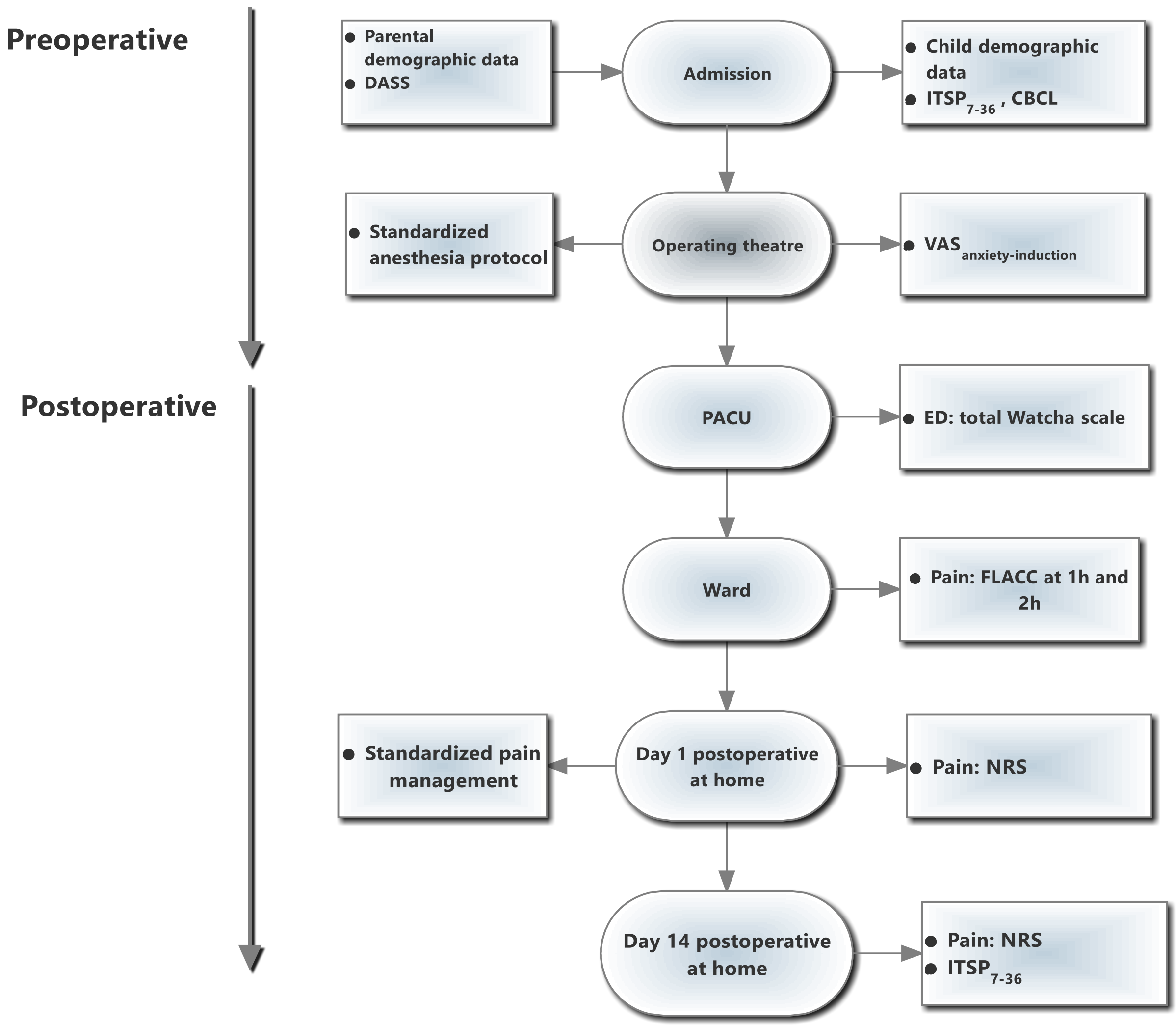

Figure 2

Flowchart inclusion and exclusion of children

Enrolment