

Comparison of short and long-term post-surgical pain and functional recovery after Nuss procedures under multimodal cryoablation, epidural and erector spinae protocols

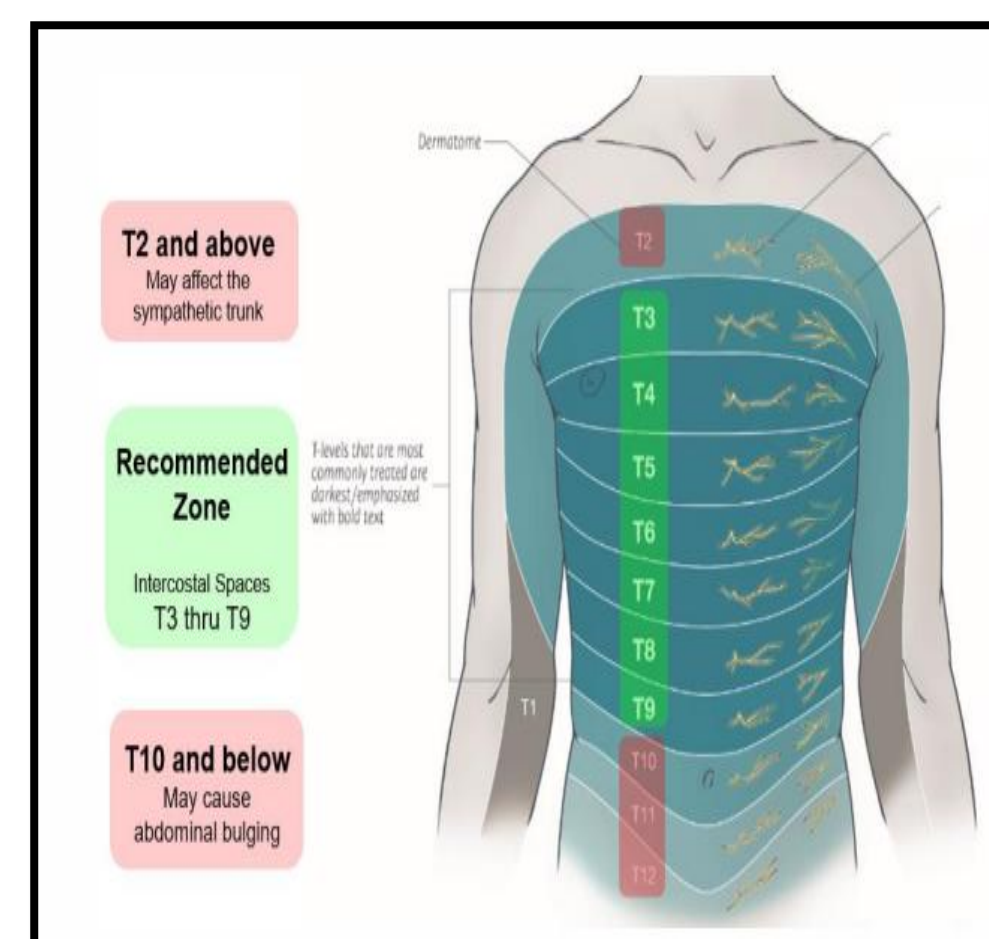
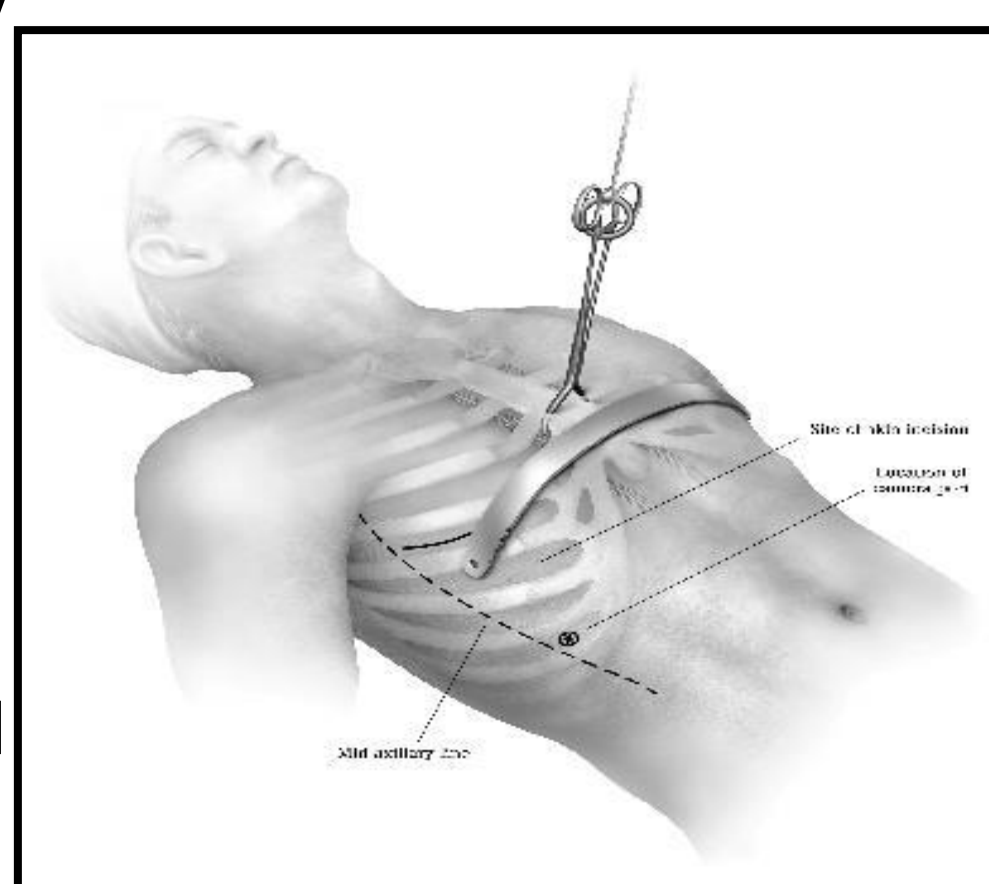
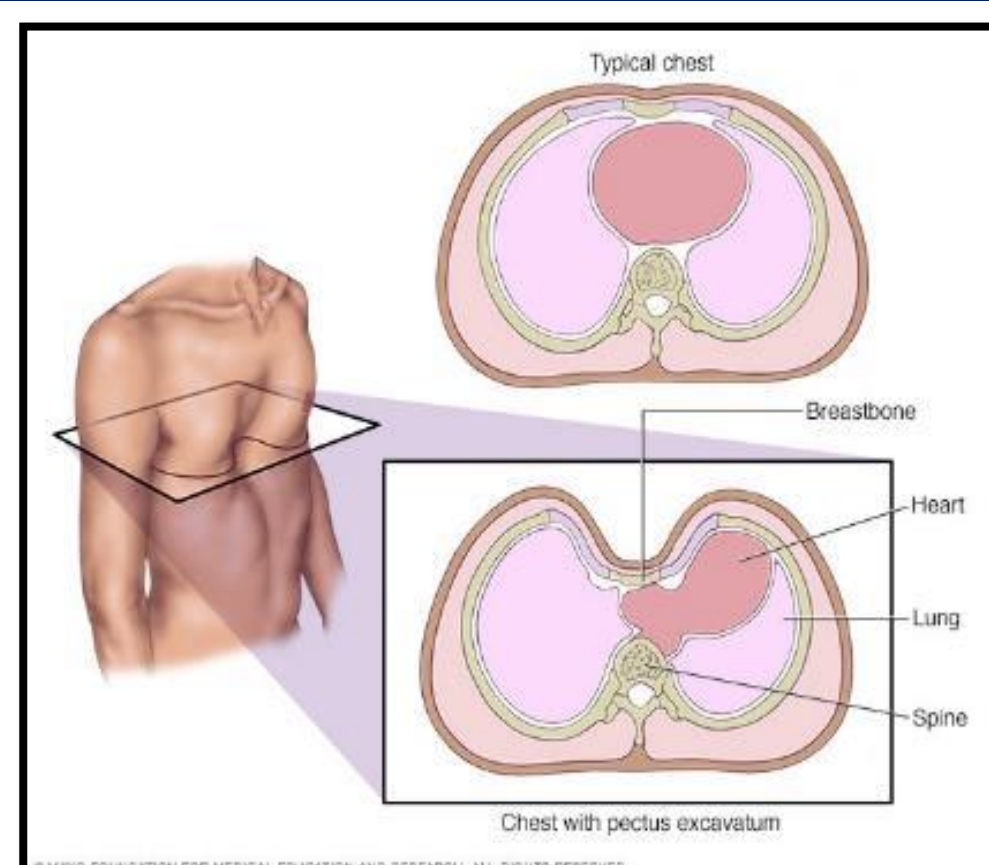
Tommy Harrington,¹ Lakshamana Vijayarajan, Siva Athitya, PhD,¹ Qing Duan, PhD,² Constance L. Monitto, MD,³ Arjunan Ganesh, MD,⁴ Radhamangalam J. Ramamurthi, MD,⁵ Susan Glynn,¹ Lili Ding, PhD,² Charlotte Walter,¹ Suryakumar Narayanasamy,¹ Vidya Chidambaran, MD, MS¹



1. Department of Anesthesiology, Cincinnati Children's Hospital 2. Biostatistics and Epidemiology, CCHMC 3. Department of Anesthesiology, Johns Hopkins 4. Department of Anesthesiology, Childrens Hospital of Philadelphia 5. Department of Anesthesiology, Lucille Packard, Stanford

Background

- Pectus excavatum is a congenital deformity where the sternum grows inward creating a sunken chest.
- In severe cases the sternum can begin compressing the heart and the lungs requiring surgical correction
- Nuss procedure:** a surgical correction method for pectus excavatum. It is considered a very painful surgery with high acute and chronic postsurgical pain (CPSP)
- CPSP is defined by the ICD-11 as **pain that develops or increases in intensity and persists >2-3 months beyond the normal healing process¹ and associated with low quality of life.**
- Three primary modes of post surgical analgesia for Nuss procedure: **Intercostal nerve cryoablation, epidurals, and erector spinae catheters.**
- There is a significant lack of multisite studies comparing these frequently used modes of analgesia for their effect on CPSP and neuropathic pain development is unknown.



We aimed to characterize and compare short- and long-term functional recovery after Nuss procedure using multimodal analgesia using cryoablation, erector spinae catheters, and epidurals in a multisite study

Hypothesis and Rationale

- Hypothesis:** Cryoablation will lead to lower acute pain and Length of stay in the acute period post-surgery, but greater incidence of Chronic Post Surgical Pain, and neuropathic symptoms.
- Rationale:** Intercostal nerve cryoablation uses freezing of intercostal nerves - while pain will be less in the acute period, the intercostal nerves will regrow after a few months leading to greater incidence of neuropathic symptoms and chronic post surgical pain

Methods

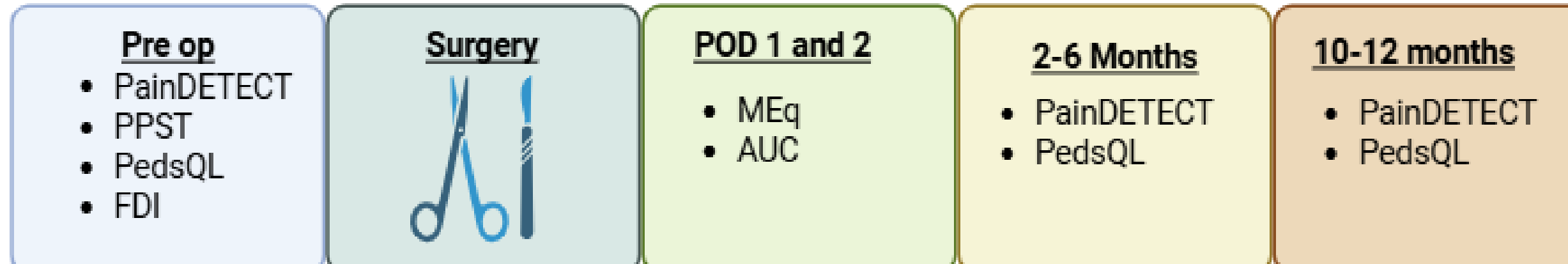
Recruitment

- Participants were recruited prospectively from 5 pediatric sites via a broader post surgical pain study (NCT02998138, NCT04031716)

Inclusion/Exclusion criteria

- Pectus patients undergoing Nuss, aged 8 years and older, no developmental delay, no chronic pain or opioid use over last 6 months
- Of 240 patients recruited, 2 were not included in analyses as data for RA was not available.

Study Methods



Surveys collected

- **PainDETECT:** a 9-item, self reported survey designed to report the presence of neuropathic pain.
- **FDI:** Functional Disability Index; a 15-item self reported measure assessing activity limitations in children ages 8-16
- **pedsQL:** pediatric quality of life index, a 23-item survey designed to assess health related quality of life in children
- **PPST:** pediatric pain screening tool; a 9-item questionnaire used to assess physical and psychosocial risk factors in youth (aged 8–18) with chronic or acute pain.

Outcomes

- **Primary: CPSP_pedsQL:** CPSP score = 1 (yes) and pedsQL score < 74.9 at 2-6 month or 10-12 month
- **Secondary: CPSP:** chronic post surgical pain score calculated from PainDETECT q2 with a score > 3; Acute pain (AUC) POD0-1; MEQ POD0-1; neuropathic symptoms and neuropathic pain

Analytic plan

- Mixed-effects model (with random site effect) used to compare covariates across regional analgesia groups
- Covariate balance between groups was assessed using absolute standardized mean differences (|SMD|) and visualized with Love plots. Balance was evaluated before and after inverse probability weighting (IPW), with |SMD| < 0.10 considered indicative of good balance and |SMD| < 0.20 considered acceptable. Mixed-effects models with IPW used to analyze associations between outcomes and regional analgesia groups with adjustment of unbalanced covariates after PS (age).

Limitations

- Inclusion of only one type of musculoskeletal surgery creates a lack of generalizability
- Cryoablation group was exclusively site-specific and although the same device was used, other attributes may be different (duration of freezing etc.)
- Retention for all groups were similar but could impact analyses

Results

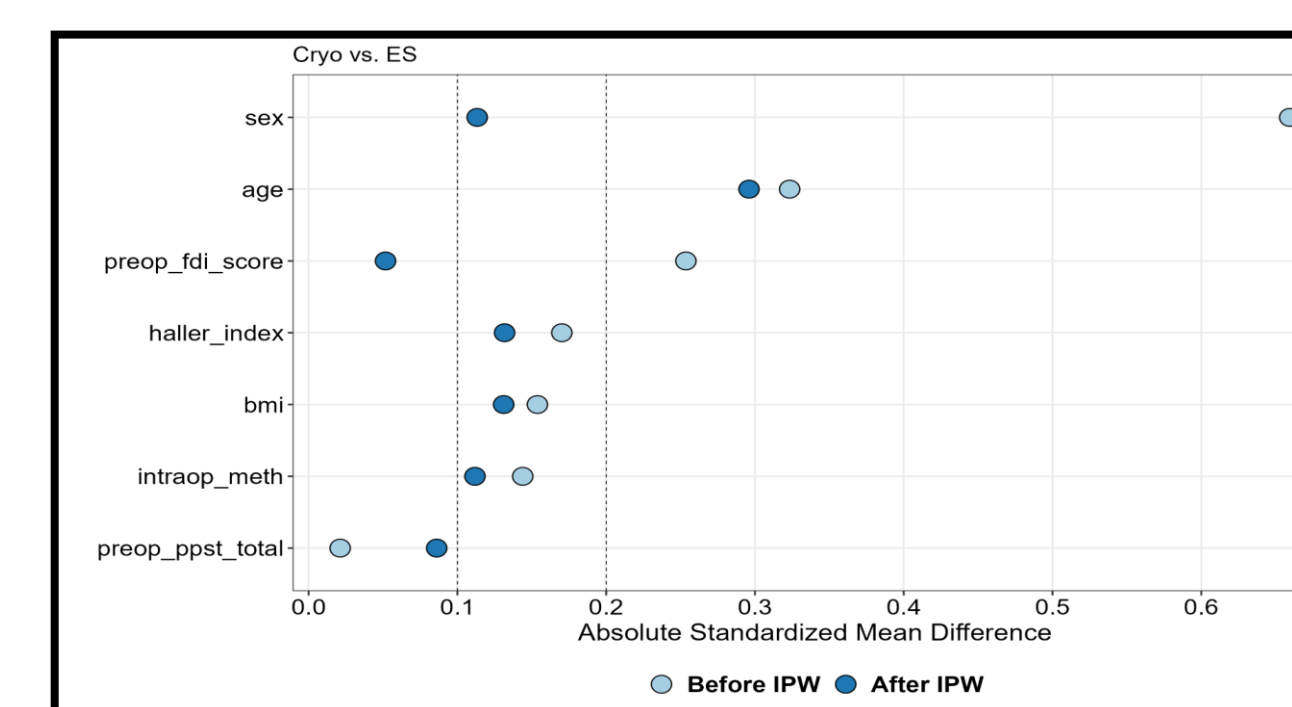
COHORT CHARACTERISTICS AND COMPARISONS BETWEEN GROUPS

Variable	N	Overall N = 238	Cryoablation N = 40	Epidural N = 46	ES Catheter N = 152	Overall p-value	cryo vs. Epidural		cryo vs. ES	
							SMD	p-value	SMD	p-value
age	235	15.7 (14.7, 17.0)	15.7 (15.0, 16.9)	15.4 (13.3, 17.0)	15.8 (14.7, 17.0)	0.311	-0.071	0.32	-0.224	0.87
Sex (Female)	54	23.0%	4 (10.0%)	13 (28.3%)	37 (24.8%)	0.09	0.48	0.03	0.34	0.04
BMI	221	18.9 (17.4, 20.8)	18.7 (17.4, 20.7)	17.8 (16.4, 19.6)	19.1 (17.6, 21.2)	0.033	0.306	0.11	-0.101	0.54
Surgical time (min)	228	96.5 (80.0, 124.5)	127.0 (102.0, 160.0)	99.0 (83.0, 123.0)	90.0 (76.0, 110.0)	<0.001	0.410	0.003	0.758	<0.001
OR time (min)	161	195.0 (176.0, 220.0)	202.0 (187.0, 227.0)	195.0 (171.0, 224.0)	189.5 (171.5, 212.5)	0.042	0.131	0.16	0.313	0.01
Preop PPST	221	0.0 (0.0, 2.0)	1.0 (0.0, 2.0)	1.0 (0.0, 3.0)	0.0 (0.0, 2.0)	0.156	-0.371	0.20	-0.002	0.72
Preop FDI	229	3.0 (0.0, 8.0)	1.5 (0.0, 11.0)	7.0 (2.0, 12.0)	3.0 (0.0, 7.0)	0.031	-0.105	0.11	0.243	0.74
haller_index	208	4.8 (3.9, 6.1)	4.9 (3.7, 5.5)	5.4 (4.1, 7.3)	4.8 (3.9, 6.2)	0.353	-0.480	0.15	-0.175	0.37
MEq (POD01)	215	0.4 (0.2, 0.5)	0.5 (0.3, 0.8)	0.3 (0.2, 0.5)	0.4 (0.2, 0.5)	0.021	0.634	0.02	0.485	0.02

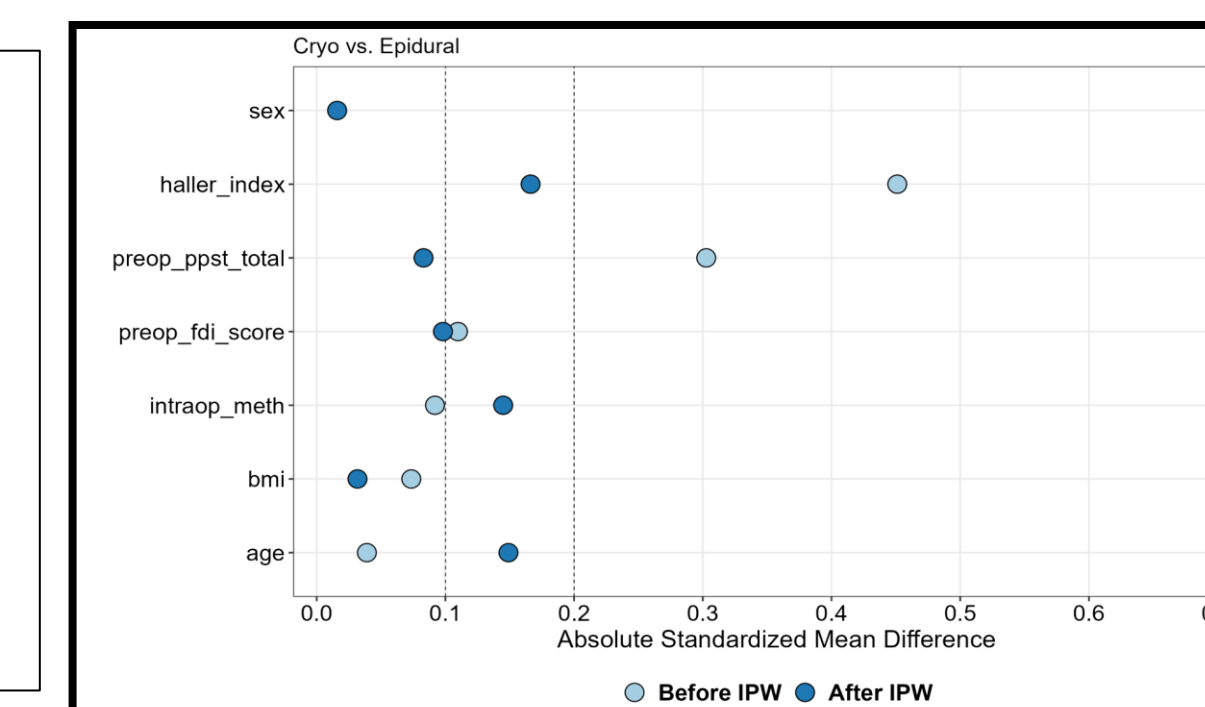
Incidence of CPSP for Cryoablation (INC), epidurals (EPI), and erector spinae catheters (ES) was 34.4%, 14.6%, and 13.3% respectively. PPST, BMI, FDI, Haller, methadone, sex and age were identified as covariates

Variable	Overall N = 238	Cryoablation N = 40	Epidural N = 46	ES Catheter N = 152	Overall p-value	Cryo vs. Epid p-value	Cryo vs. ES p-value
Acute pain_POD01	220.3 (160.7, 275.8)	115.7 (76.3, 173.6)	178.4 (109.3, 242.8)	258.2 (195.0, 288.5)	<0.001	0.026	<0.001
MEq_POD01	0.4 (0.2, 0.5)	0.5 (0.3, 0.8)	0.3 (0.2, 0.5)	0.4 (0.2, 0.5)	0.021	0.016	0.022
CPSP	86 (42.6%)	18 (62.1%)	19 (45.2%)	49 (37.4%)	0.048	0.163	0.015
Missing	36	11	4	21			
CPSP_PedsQL	35 (16.8%)	11 (34.4%)	6 (14.6%)	18 (13.3%)	0.015	0.048	0.005
Missing	30	8	5	17			
LOS	2.0 (2.0, 3.0)	2.0 (1.0, 2.5)	3.0 (3.0, 4.0)	2.0 (2.0, 2.0)	<0.001	<0.001	0.061
PainDetect Final 2-6 months					0.893	0.883	0.496
<12	157 (84.4%)	24 (80.0%)	29 (85.3%)	104 (85.2%)			
12-18	22 (11.8%)	4 (13.3%)	4 (11.8%)	14 (11.5%)			
>18	7 (3.8%)	2 (6.7%)	1 (2.9%)	4 (3.3%)			
Pain Detect Final 10-12 months					0.097	0.362	>0.999
<12	152 (92.1%)	25 (96.2%)	25 (83.3%)	102 (93.6%)			
12-18	11 (6.7%)	1 (3.8%)	3 (10.0%)	7 (6.4%)			
>18	2 (1.2%)	0 (0.0%)	2 (6.7%)	0 (0.0%)			

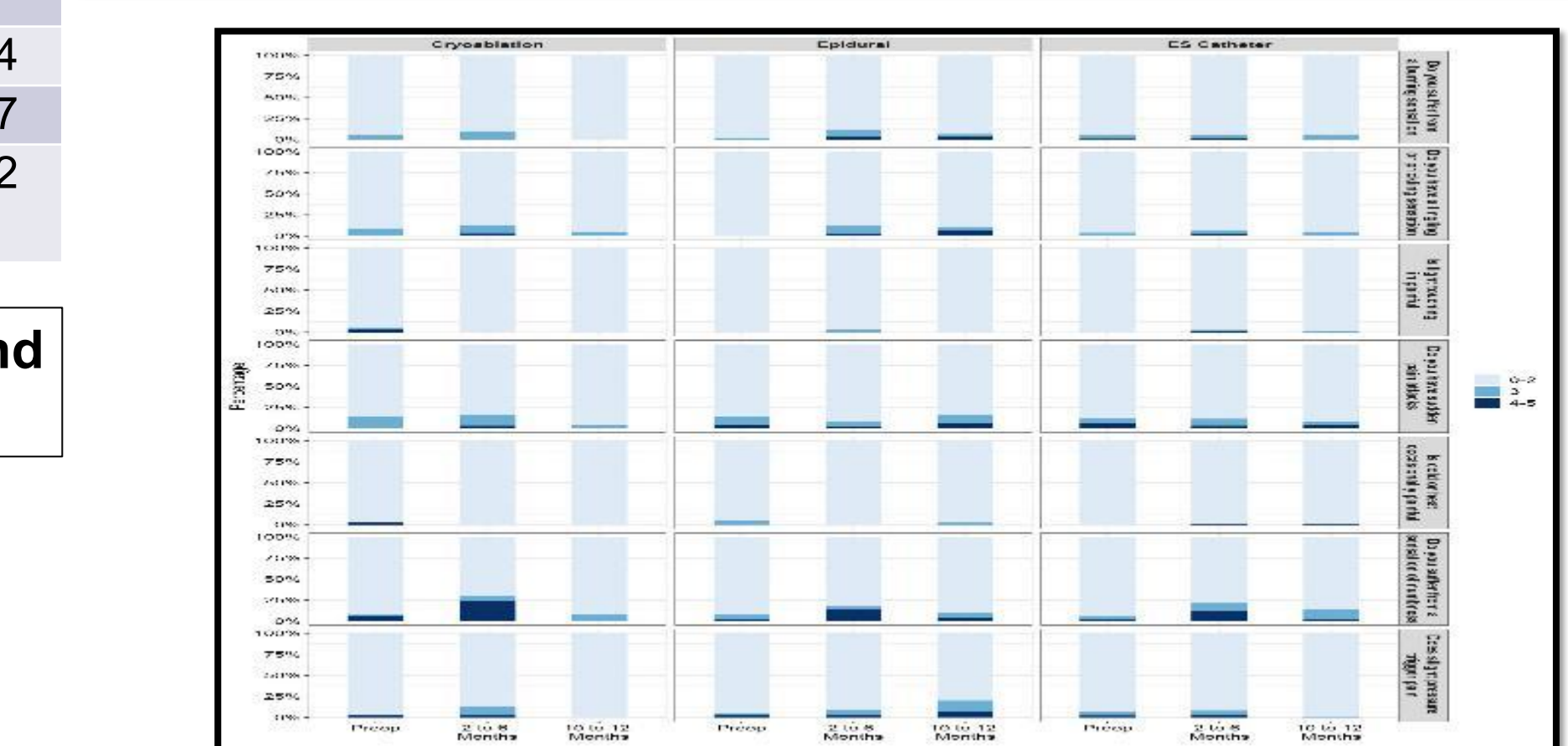
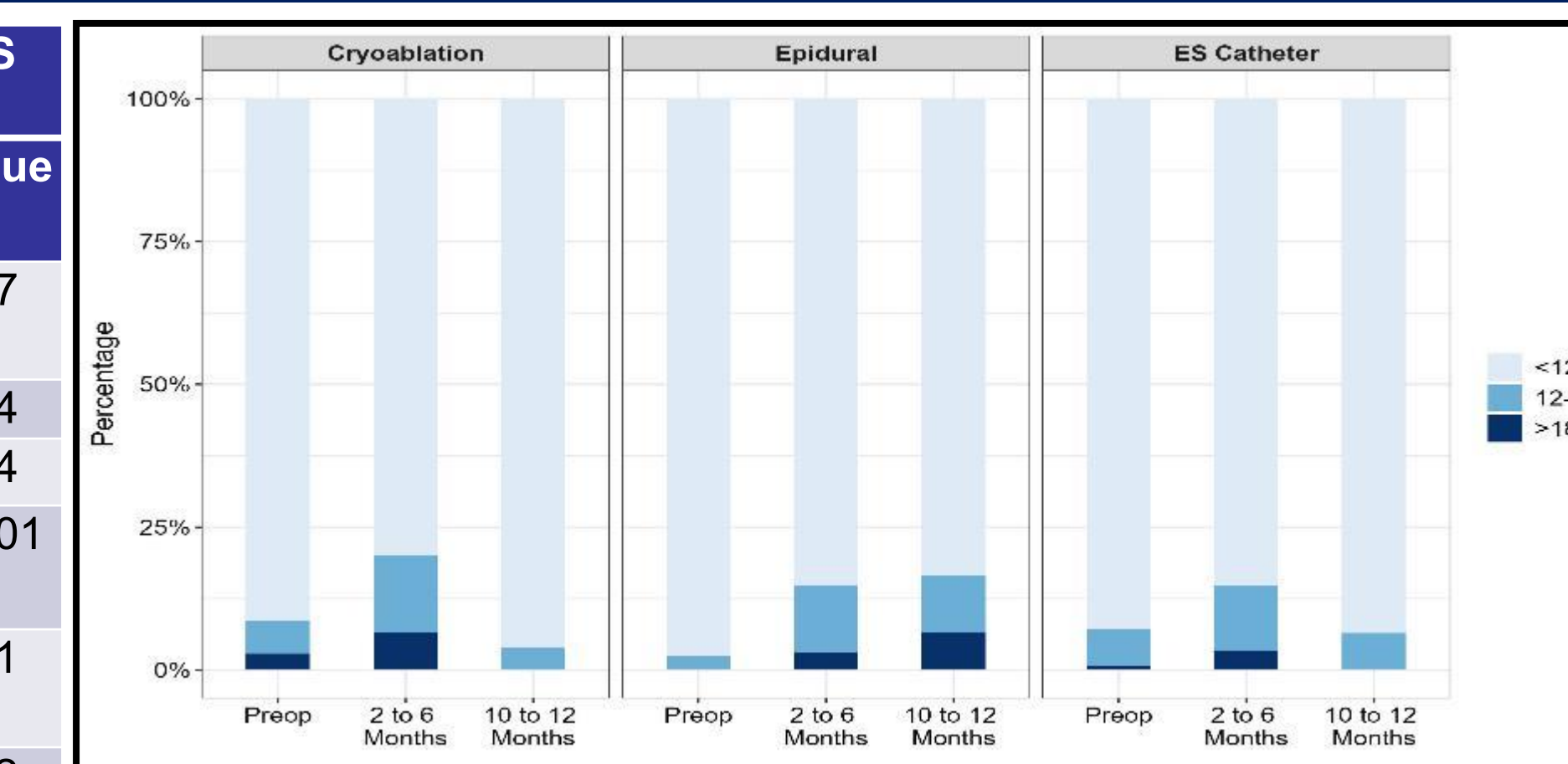
AUC, opioid use, LOS, CPSP and CPSP_PedsQL were significantly different between groups



Love plots show Covariates (PPST, BMI, FDI, Haller, methadone, sex), except age, were balanced by PS adjustment using SMD cutoff of .2



Results



There was higher incidence of reported numbness and sudden pain attacks in the INC groups 2-6 months post-op. There was higher incidence of tingling/prickling sensation and slight pressure triggered pain in the EPI group 10-12 months

Propensity score and age adjusted logistic regression

Effect	DF	Wald Chi-Square	Pr > ChiSq
Regional	2	14.14	<.001
age	1	1.11	0.29

Odds Ratio Estimates and Wald Confidence

Odds Ratio	Estimate	95% CI
Cryoablation vs ES Catheter	5.960	2.207, 16.096
Cryoablation vs Epidural	8.164	1.989, 33.507
ES Catheter vs Epidural	1.370	0.392, 4.789

Conclusions and Discussion

- Our multisite study showed better acute pain outcomes but >2-fold higher incidence of CPSP_PedsQL in cryoablation vs.ES and EPI groups.
- Logistic regression (propensity score and age adjusted) showed higher odds for CPSP_PedsQL in the INC compared to both ES and EPI groups.
- Future RCTs are needed to understand long term consequences of INC in children undergoing Nuss procedures.

References

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