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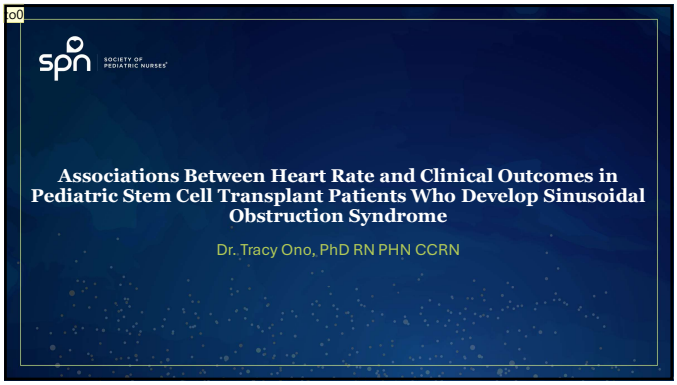
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Associations Between Heart Rate and Clinical Outcomes in Pediatric Stem Cell Transplant Patients Who Develop Sinusoidal Obstruction Syndrome
Dr. Tracy Ono, PhD RN PHN CCRN

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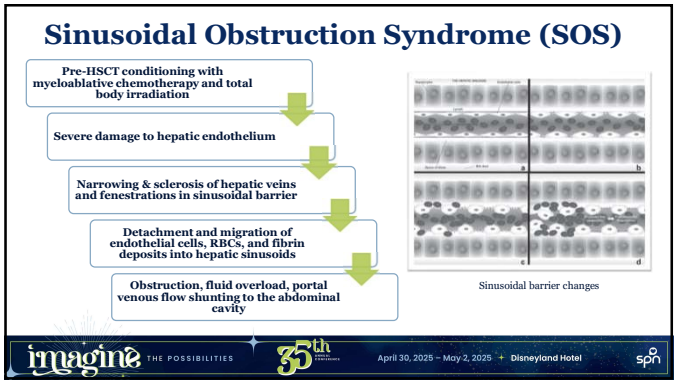
Sinusoidal Obstruction Syndrome (SOS)
Pre-HSCT conditioning with myeloablative chemotherapy and total body irradiation
Severe damage to hepatic endothelium
Narrowing & sclerosis of hepatic veins and fenestrations in sinusoidal barrier
Detachment and migration of endothelial cells, RBCs, and fibrin deposits into hepatic sinusoids
Obstruction, fluid overload, portal venous flow shunting to the abdominal cavity
Sinusoidal barrier changes
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Slide 2

to0 Share how you got interested in this “just to bring it home for you, this how I got interested in this as a bedside nurse…”

tracy ono, 2025-04-03T17:06:35.673

Significance

Morbidity & Mortality	Diagnosis	Signs & Symptoms	Treatment
• 2 to 6-fold more likely in children • 30-60% progress to severe SOS • Severe SOS mortality >80%	• Dependent on clinical signs & symptoms • 20% late onset • Anicteric SOS (aSOS) in 30% of pediatric cases	• Hyperbilirubinemia • Hepatomegaly • Ascites • RUQ pain • Refractory thrombocytopenia • Reversal of portal flow or increased portal wedge pressure	• Supportive care • Defibrotide

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Methods

Purpose	• Evaluate associations between longitudinal heart rate changes and SOS up to days 14 and 28 following HSCT
Design	• Retrospective cohort from electronic medical record (EMR) data
Sample	• 180 children, 6 months to 19 years • HSCT January 1, 2015 – January 1 , 2019 for malignancy
Data	• ICD 9 & 10 codes • Transplant team records

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Measures

Measure	Measurement
Outcome of Interest Heart rates over 14 and 28 days following HSCT	Beats/min (bpm) justified relative to date and time of HSCT "*zero time*"
Exposure of Interest	Diagnosis of SOS (binary measure: diagnosed by clinical guidelines)
Covariates Time since HSCT Age (in years) Malignancy type Preconditioning chemotherapy Sociodemographic variables	 Days Four quartiles by age Hematologic vs solid tumor Alkylating agents vs purine or monoclonal antibodies Race, ethnicity, sex, poverty (LAC low/high SES)

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Data Analysis

1. Sample characteristics – association between covariates and SOS
2. Visualizations – scatter plots
3. Associations
   - Age
   - SOS
   - Time
4. Multivariable Interaction model
5. Predictive Analysis

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Results

Study Cohort Demographics

	Total Sample (n=180)		SOS (n=28)		Not SOS (n=152)		
	n	%	n	%	n	%	p-value
Age (Quartiles)							
6 months – 2.5 years (Q1)	45	25.0	10	22.2	35	77.8	0.3655
2.5 years – 6 years (Q2)	46	25.6	4	8.7	42	91.3	
6 years – 11 years (Q3)	44	24.4	7	15.9	37	84.1	
11 years – 19 years (Q4)	45	25.0	7	15.6	38	84.4	
Race							
White	78	43.3	15	19.2	63	80.8	0.2342
Non-White	102	56.7	13	12.7	89	87.3	
Ethnicity							
Hispanic	77	42.8	14	18.2	63	81.8	0.4006
Non-Hispanic	103	57.2	14	13.6	89	86.4	
Sex							
Male	89	49.4	15	16.9	74	83.1	0.6346
Female	91	50.6	13	14.3	78	85.7	
HSCT Type							
Autologous	93	51.7	2	2.2	91	97.8	<0.0001*
Allogeneic	87	48.3	26	30.0	61	70.0	
Malignancy Type							
Hematologic	93	51.7	26	28.0	67	72.0	<0.0001*
Solid Tumor	87	48.3	2	2.3	85	97.7	
Chemotherapy Class							
Alkylating Agents	162	90.0	25	15.4	137	84.6	0.8910
Purines/ monoclonal antibodies	18	10.0	3	16.7	15	83.3	
Poverty							
LAC low SES	72	40.0	8	11.1	64	88.9	0.3523
LAC high SES	54	30.0	11	20.4	43	79.6	
Outside LAC	54	30.0	9	16.7	45	83.3	

* $p \leq 0.05$ LAC=Los Angeles County, SES=socioeconomic status

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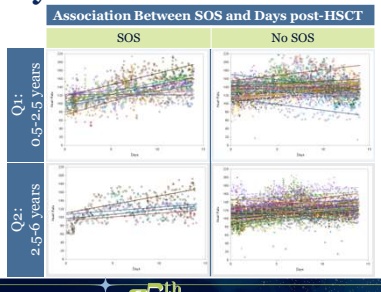
Data Analysis: Heart Rates Over 14 days



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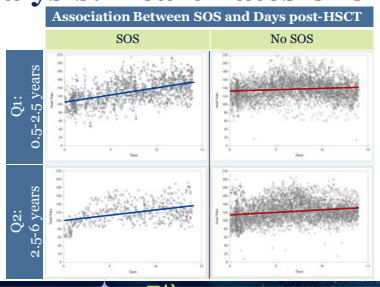
Data Analysis: Heart Rates Over 14 days



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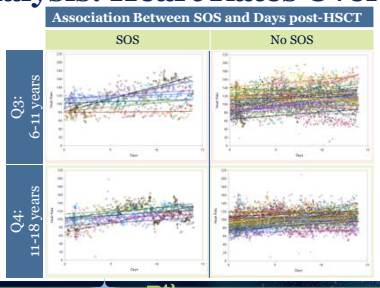
Data Analysis: Heart Rates Over 14 days



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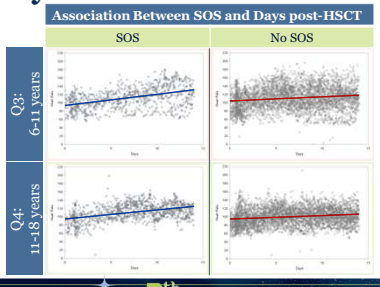
Data Analysis: Heart Rates Over 14 days



Heart Rates Over 28 days

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14-day Multivariable Interaction Model

	Mean HR (Std Error, p-value)
Malignancy	
Hematologic (vs Solid tumor)	-7.9220 (2.5754, 0.0021*)
Sex	
Male (vs Female)	-21.1519 (2.1568, 0.3184)
Race	
Non-white (vs White)	-0.9801 (2.2355, 0.6611)
Ethnicity	
Non-Hispanic (vs Hispanic)	0.3251 (2.2348, 0.8844)
Poverty	
LAC low SES	-0.3946 (2.6186, 0.8802)
Outside LAC	-4.1178 (2.7308, 0.1316)

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14-day Multivariable Interaction Model

Covariate	Mean HR (Std Error, p-value)
HR Intercept	104.84
SOS	
Affected (vs unaffected)	1.3963 (5.9925, 0.8158)
Zero time (continuous)	0.8828 (0.0617, <0.0001*)
SOS*zero time (interaction)	1.1465 (0.1501, <0.0001*)
Age	
Quartile 1 (0.5 – 2.5 years)	32.3718 (3.7235, <0.0001*)
Quartile 2 (2.5 – 6 years)	11.7986 (3.4946, 0.0007*)
Quartile 3 (6 – 11 years)	5.9382 (3.4406, 0.0844)
Quartile 4 (11 – 18 years, reference group)	0

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14-day Multivariable Interaction Model

Covariate	Mean HR (Std Error, p-value)
Interaction of SOS by Age Quartile	
SOS*Age Quartile 1	-22.9501 (7.9692, 0.0040*)
SOS*Age Quartile 2	-9.0913 (9.6046, 0.3439)
SOS*Age Quartile 3	-7.3832 (8.4653, 0.3831)
SOS*Age Quartile 4	0
Interaction of Time by Age Quartile	
*Zero time**Age Quartile 1	-0.5568 (0.09035, <0.0001*)
*Zero time**Age Quartile 2	0.4166 (0.08862, <0.0001*)
*Zero time**Age Quartile 3	0.2001 (0.0906, 0.0272*)
*Zero time**Age Quartile 4	0
3-way Interaction of SOS, Time by Age Quartile	
SOS**Zero time**Age Quartile 1	1.9545 (0.1975, <0.0001*)
SOS**Zero time**Age Quartile 2	-0.0815 (0.2431, 0.7373)
SOS**Zero time**Age Quartile 3	0.2490 (0.2190, 0.2554)
SOS**Zero time**Age Quartile 4	0

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14-day Multivariable Interaction Model

Covariate	Mean HR (Std Error, p-value)
HR Intercept	**104.84**
SOS	
Affected (vs unaffected)	1.3963 (5.9925, 0.8158)
Zero time (continuous)	0.8828 (0.0617, <0.0001*)
SOS**zero time* (interaction)	1.1465 (0.1501, <0.0001*)

+3.43 → **108.27 bpm**

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14-day Heart Rate Trajectory

SOS Affected															
Age Quartile 1	Day 1	Day 7	Day 14	Age Quartile 2	Day 1	Day 7	Day 14	Age Quartile 3	Day 1	Day 7	Day 14	Age Quartile 4	Day 1	Day 7	Day 14
Intercept	104.84	104.84	104.84		104.84	104.84	104.84		104.84	104.84	104.84		104.84	104.84	104.84
SOS Affected	1.3963	1.3963	1.3963		1.3963	1.3963	1.3963		1.3963	1.3963	1.3963		1.3963	1.3963	1.3963
Zero time	0.8828	6.1796	12.3592		0.8828	6.1796	12.3592		0.8828	6.1796	12.3592		0.8828	6.1796	12.3592
SOS*Zero time	1.1465	8.0255	16.051		1.1465	8.0255	16.051		1.1465	8.0255	16.051		1.1465	8.0255	16.051
SOS*Age	-22.9503	-22.9503	-22.9503		-9.0913	-9.0913	-9.0913		-7.3832	-7.3832	-7.3832		0	0	0
Zero time*Age	-0.5568	-3.8976	-7.7952		0.4166	2.9162	5.8324		0.2001	1.4007	2.8014		0	0	0
SOS*Zero time*Age	1.9545	13.6815	27.363		-0.08154	-0.57078	-1.14156		0.249	1.743	3.486		0	0	0
Age: 0.0-2.5 years	32.3718	32.3718	32.3718	Age: 2.6-6 years	11.7986	11.7986	11.7986	Age: 6.1-11 years	5.9182	5.9182	5.9182	Age: 11-19 years	0	0	0
Predicted Heart Rate	110.085	139.647	163.636		111.308	125.4941	142.0446		107.5697	122.1401	139.4889		108.2656	120.4414	134.6465
Unaffected															
Age Quartile 1	Day 1	Day 7	Day 14	Age Quartile 2	Day 1	Day 7	Day 14	Age Quartile 3	Day 1	Day 7	Day 14	Age Quartile 4	Day 1	Day 7	Day 14
Intercept	104.84	104.84	104.84		104.84	104.84	104.84		104.84	104.84	104.84		104.84	104.84	104.84
SOS Affected	0	0	0		0	0	0		0	0	0		0	0	0
Zero time	0.8828	6.1796	12.3592		0.8828	6.1796	12.3592		0.8828	6.1796	12.3592		0.8828	6.1796	12.3592
SOS*Zero time	0	0	0		0	0	0		0	0	0		0	0	0
SOS*Age	0	0	0		0	0	0		0	0	0		0	0	0
Zero time*Age	-0.5568	-3.8976	-7.7952		0.4166	2.9162	5.8324		0.2001	1.4007	2.8014		0	0	0
SOS*Zero time*Age	0	0	0		0	0	0		0	0	0		0	0	0
Age: 0.0-2.5 years	32.3718	32.3718	32.3718	Age: 2.6-6 years	11.7986	11.7986	11.7986	Age: 6.1-11 years	5.9182	5.9182	5.9182	Age: 11-19 years	0	0	0
Predicted Heart Rate	137.5378	139.4958	141.7758		117.938	125.7344	134.8302		111.8611	118.3585	125.9588		105.7228	111.0196	117.1092

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14-day Heart Rate Trajectory

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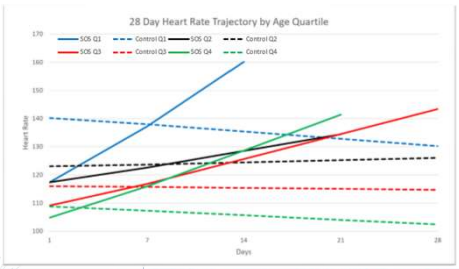
28-day Heart Rate Trajectory



28-day Multivariable Interaction Model & Trajectory

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Limitations

- Evaluated real-time heart rates during the first 28 days following HSCT.
- Clinically collected data
- Single center study in patients transplanted for malignancies

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Key Takeaways & Clinical Implications

- 1st study to evaluate HR data as an *early* indicator of SOS
- Heart rate pattern changes from HSCT patients' baselines warrant further exploration
- Early SOS recognition improves care and patient outcomes for HSCT recipients
- Routinely collected data may have predictive value

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References

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