Implementing High Flow Nasal Cannula Therapy in Acute Care Settings–This May Get Heated!

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Saturday, July 22, 2017, 4:15 - 5:30 pm

Disclosure

We have no relevant financial relationships with the manufacturers of any commercial products and/or provider of commercial services discussed in this CME activity.

We do not intend to discuss an unapproved/investigative use of a commercial product/device in this presentation.

Learning Objectives

- Review fundamental high flow nasal cannula (HFNC) concepts and current evidence on its use for pediatric respiratory support.
- Develop an approach to implement HFNC in pediatric wards in both university-affiliated and community hospital settings.
- Build an approach to address common challenges with implementing HFNC outside the intensive care unit.

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Session Timeline

4:15 – 4:20 Introduction
4:20 – 4:30 Literature Highlights
4:30 – 4:35 HFNC in Community Hospitals
4:35 – 4:55 HFNC in University Affiliated Hospitals
4:55 – 5:25 Panel Discussion
5:25 – 5:30 Conclusion

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HFNC Literature Highlights

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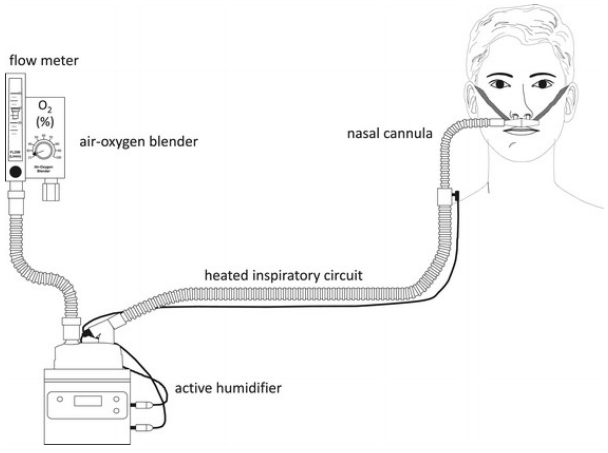
High Flow Nasal Cannula

- Delivery system for heated and humidified medical gas mixtures
- This "conditions" gas mixtures leading to less drying of nasal tissues.



Nishimura M. High flow nasal cannula oxygen therapy in adults. J of Intens Care (2015) 3:15

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Why is humidity important?

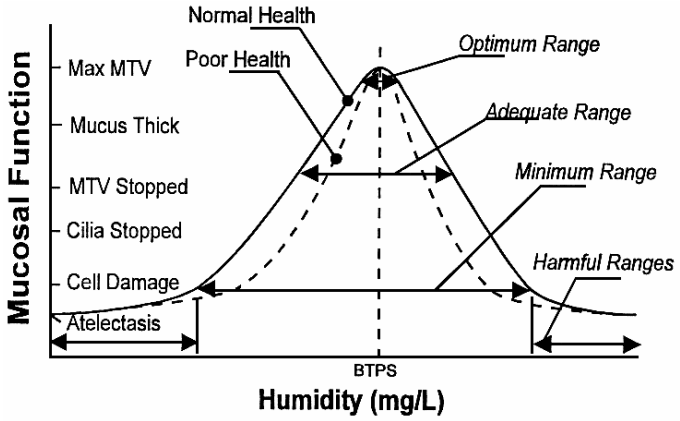

Figure 2. A model of how mucosal function varies with the deviation of inspired humidity from core temperature and 100% relative humidity. It illustrates a continuum of mucosal dysfunction with any deviation from optimal humidity. The curve narrows with poor health. The levels of dysfunction may be used to define categories of humidity ranges. MTV, mucociliary transport velocity. BTPS, body temperature atmospheric pressure and saturated with water vapor.

Williams R, et al. Relationship between the humidity and temperature of inspired gas and the function of the airway mucosa. Crit Care Med. 1996 Nov;24(11):1920-9.

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PEEP effect

- High flow nasal cannula does generate some PEEP, but variable
  - Influenced by multiple factors include, tightness of cannula fit in nares, weight, whether mouth is open vs closed.
- In general- younger patients get more PEEP for any given flow rate

- Locke RG, Wolfson MR, Shaffer TH, Rubenstein SD, Greenspan JS. Inadvertent administration of positive end-distending pressure during nasal cannula flow. Pediatrics 1993; 91: 135–8
- Spence KL, Murphy D, Kilian C, McGonigle R, Kilani RA (2007) Highflow nasal cannula as a device to provide continuous positive airway pressure in infants. J Perinatol 27:772–775.
- Wilkinson DJ, Andersen CC, Smith K, Holberton J (2008) Pharyngeal pressure with high-flow nasal cannulae in premature infants. J Perinatol 28:42–47
- Parke R, McGuiness S, Eccleston M. Nasal high-flow therapy delivers low level positive airway pressure. Br J Anaesth 2009; 103:886-90.

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Generation of PEEP? Neonatal studies

Pharyngeal pressure with high-flow nasal cannulae in premature infants

DJ Wilkinson[1,2], CC Andersen[1,3], K Smith[4] and J Holberton[1]

- Flow rate and weight affected pressure attained, mouth opening did not

High-flow nasal cannula as a device to provide continuous positive airway pressure in infants

KL Spence[1], D Murphy[1], C Kilian[1], R McGonigle[1] and RA Kilani[2]

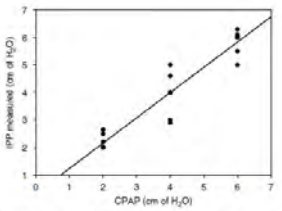

Figure 1 Reflects the relation of intrapharyngeal pressure (IPP) as a measure of continuous positive airway pressure (CPAP). This regression line graph represents all the data points at each CPAP. R^2 is 0.91

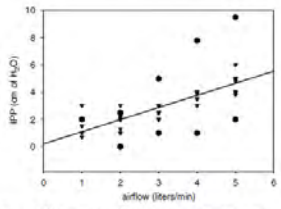

Figure 2 This regression line plot represents the correlation between airflow and intrapharyngeal pressure (IPP) generated in 12 patients. The R^2 is 0.47. Two patients with extreme values are highlighted by the large dark circles. The other ten patients are represented by triangles.

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Generation of PEEP? Adult studies

Nasal high-flow therapy delivers low level positive airway pressure

R. Parke[1]*, S. McGuinness[1] and M. Eccleston[2]†

- Amount of pharyngeal pressure generated was variable.
- Required 35 Liters/ flow to generate up to max of 5 cm H2O PEEP, much less than what is seen in neonates.
- Large variability dependent on whether mouth was open.

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CO_2 Washout

- Gas flow rates that exceed inspiratory flow rates cause a "washout " of the nasopharyngeal cavity during late expiratory phase and end expiratory pause in the breathing cycle.
- This "washout" or purge of the anatomic dead space that does not take part in gas exchange removes expiratory gas that is high in CO_2.
- Subsequent breaths will be composed of less re-breathed expiratory gas (high in CO_2, low in oxygen) and more delivered cannula gas .

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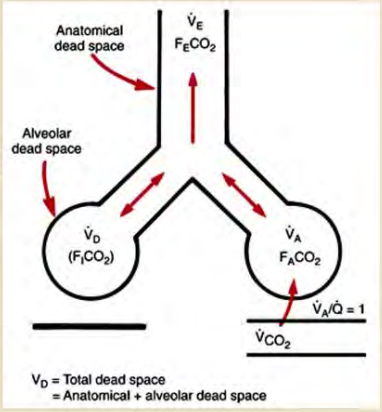
Anatomic vs Physiologic Dead Space

Dead Space

- **Dead Space** – some of the inspired air fills the conducting respiratory passageways and never contribute to gas exchange in the alveoli.
  - **Anatomical Dead Space** (V_D)– volume in conducting zone (~150 ml).
  - **Alveolar Dead Space** – volume of air in alveoli that have ceased to act in gas exchange (due to alveolar collapse or obstruction by mucus, for example).
  - **Total Dead Space** = anatomical dead space plus alveolar dead space.



http://web.squ.edu.om/med-Lib/MED_CD/E_CDs/anesthesia/site/content/figures/2015f21

Conditioned Oxygen Mixtures

- Conditioned oxygen mixtures (ie warmed/ humidified) is less likely to induce bronchospasm and decreased lung compliance
  - Campbell EJ, Baker MD, Crites-Silver P. Subjective effects of humidification of oxygen for delivery by nasal cannula. A prospective study. Chest. 1988;93(2):289-93.
  - Berk JL, Lenner KA, McFadden Jr ER. Cold-induced bronchoconstriction: role of cutaneous reflexes vs direct airway effects. J Appl Physiol. 1987;63(2):659–64.
  - Fontanari P, Burnet H, Zattara-Hartmann MC, Jammes Y. Changes in airway resistance induced by nasal inhalation of cold dry, dry, or moist air in normal individuals. J Appl Physiol. 1996;81:1739-43.
  - Greenspan JS, Wolfson MR, Shaffer TH. Airway responsiveness to low inspired gas temperature in preterm neonates. J Pediatr. 1991;118(3):443-5.
- Conditioned oxygen mixtures improve mucociliary function, allows for clearance of secretions and are associated with less atelectasis.
  - Salah B, Dinh Xuan AT, Fouilladieu JL, Lockhart A, Regnard J. Nasal mucociliary transport in healthy subjects is slower when breathing dry air. Eur Respir J. 1988;1(9):852–5.

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HFNC Outcomes

- ICU Utilization
  - Instituting a HFNC guideline outside the ICU may be associated with increased use of HFNC without a change in length of stay, or ICU transfer rate
    - Reise, et al. Clinical Outcomes of Bronchiolitis After Implementation of a General Ward HFNC Guideline. Hosp Peds Vol7, Issue 4, April 2017
  - Patients who will require ICU admission can be identified in 1st hour of admission by HR and RR changes.
    - Mayfield S, et al. HFNC oxygen therapy for infants with bronchiolitis: pilot study. J Paediatr Child Health. 2014 May;50(5):373-8.

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HFNC Outcomes

- Predictors of HFNC Failure
  - High Fio2 needs, prior intubation, and cardiac co-morbidities are associated with HFNC failure
    - Betters, K. A., Gillespie, S. E., Miller, J., Kotzbauer, D. and Hebbar, K. B. (2017), High flow nasal cannula use outside of the ICU; factors associated with failure. Pediatr Pulmonol., 52: 806–812. doi:10.1002/ppul.23626
  - Hypercarbia and lesser degree of tachypnea at onset of HFNC along with no change after HFNC initiation may be associated with HFNC failure
    - Abboud, et al. Predictors of Failure in Infants with Viral Bronchiolitis Treated with High-Flow High-Humidity, Nasal Cannula Therapy. Ped Crit Car Med. 2012 Nov;13(6):e343-9. doi: 10.1097/PCC.0b013e31825b546f.

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HFNC Outcomes

- Decreasing Intubation Rates
  - Early use of HFNC in the ED may reduce intubation rates
    - Canares, T, et al. Going with the Flow: Respiratory Care in the Pediatric Emergency Department. Rhode Island Medical Journal, Jan 2014.
  - HFNC outside the ICU may result in a trend toward decreasing intubation
    - Wilson, et al. Effects of a Clinical Pathway for HFNC Therapy in Bronchiolitis Outside of the Intensive Care Unit. Abstract presentation October 12, 2014.
  - HFNC use in the ICU reduces the need for intubation
    - Schibler, et al. Reduced Intubation Rates for Infants After Introduction of High-Flow Nasal Prong Oxygen Delivery. Intensive Care Med.2011 May;37(5):847-52., .
    - McKiernan C , etal High flow nasal cannulae therapy in infants with bronchiolitis. J Pediatr. 2010 Apr;156(4):634-8.
    - A Kawaguchi et al. The Clinical Impact of Heated Humidified High-Flow Nasal Cannula on Pediatric Respiratory Distress. Pediatr Crit Care Med 18 (2), 112-119. 2 2017.

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HFNC in Community Hospitals

Nicole Rochester, MD

Former Medical Director of Holy Cross Hospital, Children's National Health System

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Phase I: Preparation

- Review literature
- Review current practice (Listserv, protocols from other institutions)
- Engage stakeholders
  - Pediatric Hospitalist group
  - Pediatric residents
  - Respiratory Therapy
  - Nursing (including leadership)
  - Neonatology
  - Pediatric Emergency Dept.
  - CNMC Pediatric ICU

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Phase I: Preparation

- Develop protocol
- Vet protocol with stakeholders
- Finalize protocol
- Challenges
  - Determining inclusion/exclusion criteria
  - No evidence for flow rates
  - Equipment needs
  - Training/Nurse staffing

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Phase II: Implementation

- Review of protocol and feedback from stakeholders
- In-service (hospitalists, pediatric residents, nurses, respiratory therapy)
- Go-live!
- Challenges
  - Training (new residents q8 weeks, nursing, RT)
  - Pressure to admit excluded patients
  - Low volume

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Phase III: Study

- Email Medical Director with concerns/problems
- Chart review
- Debrief at monthly physician group meetings
- Select Metrics
  - Total cases
  - Demographics
  - LOS
  - Transfer to ICU
  - Readmissions

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HFNC in University Affiliated Settings

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Can you implement HFNC outside the ICU?

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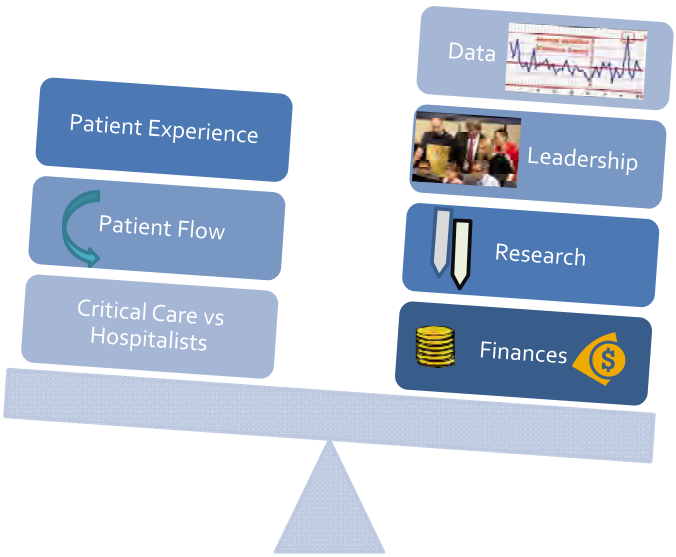
What's going to tip the scale at your institution?



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Project Timeline

Month	Task
July – Sept 2015	COE Team Formed
Oct – Dec 2015	Financial data analysis IRB completed, Chart Review tool developed
Jan – March 2016	Chart Review and Data Analysis conducted Lit Review, Draft Protocol Developed
March – July 2016	Clinical Decision Support Tools Developed ICU Chief and MUD Approval Hospitalist Division Chief Approval Requested Pulm Feedback
Aug 2016	Staff Training/Education Plan Developed Finalize ROI Analysis
Sept 2016	HFNC Orderset Submitted Cerner Documentation submitted ICU Faculty Presentation 9/14
Oct 2016	Nursing Practice Council Revise IRB
Nov - Dec 2016	Med Exec Cmte Presentation Conduct Staff Education – Physician, RN, RT
Jan 2017	Planned Go-Live

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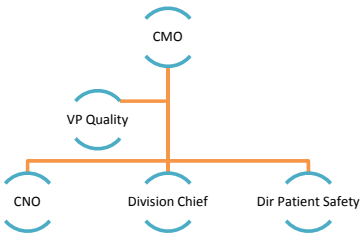
Learn from our mistakes!

- Start at the top
  - Understand your Org chart
  - Secure leadership commitment
- Review recent safety events/RCAs to get a pulse
- What is the data these leaders want to see?



- Build rapport in small groups
  - Identify allies and adversaries
  - Are you *asking me* or *telling me* to do this?
- Talk with your Financial Departments – but don't lead with this

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Lurie Children's Hospital: Developing a new model of inpatient care

- FY 2015-16 Goals
  - Investigate the desirability and feasibility of a new model of inpatient care for medical patients to address high-census issues & increased need for attending physician presence on acute care floors
- Process
  - Discussed with multiple peer institutions and local multidisciplinary team assembled
  - Census data & finances analyzed
  - Explored multiple models of care (Intermediate Care, Third General Medicine Team, Subspecialty collaboration, etc.)
  - **Seasonal 24/7 Hospitalist Service proposal accepted Jan 2016**

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Background: Inpatient Challenges

Volume Surges in ED/UC/Inpatient/ICUs	• ICU and IP Overflow and ED Surges • Surges → Require Moonlighting → Places New Providers in New Roles
Higher Demands for ICU Level Care	• Quaternary Care Center; Growing Referrals; High Surgical Volumes • Growth in Population of Medically Complex Children
Changing landscape of inpatient vs. outpatient medicine	• Increasing need for inpatient "generalist" coordinating care
Inpatient Cohorting is Diagnosis Based vs. Acuity Based	• Acute Care Units Have Become Highly Specialized • No existing system for cohorting higher acuity patients
Service Sizes Highly Variable	• Extended Rounding; Delays Discharges

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Background: Intermediate Care

- Definitions
  - Published 2004 AAP Guidelines…Varies in Practice
    - *"Care for the sickest general ward patients and the most stable ICU patients"*
    - Medical >>> Post-Surgical
    - Non-invasive monitoring (i.e. no arterial lines, CVPs)
    - Greater Intensity of Nursing Care than IP


AMERICAN ACADEMY OF PEDIATRICS

CLINICAL REPORT

Admission and Discharge Guidelines for the Pediatric Patient Requiring Intermediate Care

- Intensive (ICU) vs. Intermediate Care (IMCU)
  - Over 300 Pediatric Intensive Care Units in the U.S.
  - Relatively Few Children's Hospitals with Intermediate Care Units
    - Only one of the U.S. News Top 10 Children's Hospitals (Boston)
    - Hospitals with Pediatric IMCUs
      - **Boston Children's**, Vanderbilt, Penn State Hershey, Baystate, Loma Linda, Inova Fairfax, Dayton Children's, University of Tennessee, Medical University of South Carolina

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Developing an Intermediate Care Unit

- Define Patient Population
  - Sicker general ward patients and selected "PICU patients"
- Develop Admission/Exclusion Criteria
  - Use comparable institutions as a model (e.g., Boston & Vanderbilt IMCU)
  - Consider Site Visit to comparable institution
- Reevaluate PICU/Inpatient Distinctions
  - Need to address the existing dogmas before unit is opened:
    - Nebulizations: 20mg/hr cont. albuterol, cont. albuterol <1 yo patient; FiO2 >50%
    - Respiratory Support: HFNC/BiPAP, BiPAP titrations (failed PSG)
    - Intense Nursing: Ingestions (frequent RN assessments or q1hr accuchecks)

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Developing an Intermediate Care Unit

- Define Unit & Work Flow Model
  - 4-10 bed closed unit
  - 24/7 HBM physician coverage (+/- residents)
  - Strict admission/exclusion criteria
  - Flexible & Expedited Transfers to/from PICU
  - Daily IMCU/PICU bed huddle
- Define RN and RT Staffing
  - Nurse to patient ratio: 2:1 to 3:1 (based on acuity)
  - Dedicated RT
- Recruit, educate, and train staff (MDs, RNs, RTs)
  - HBM Faculty: PICU service prior to joining IMCU faculty
  - RN/RT: In-service in HFNC/NiPPV; on-boarding with PICU RN/RT

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Metrics for Evaluating Success

- Bounce back to ICU rate
- CAT call/floor CODE event rate
- Rate of denials and surgical cancellations during peak census
- Length of stay by unit, service, and diagnosis
- Level of care assignments and impact on revenue
- Family and staff satisfaction

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Preliminary Needs Assessment: CY 2013

IMCU Patient Search	Admits
Total 2013 Admits	12,470
FILTERED OUT: Ventilators, Mannitol	10,989
SELECTED SERVICES: Visited PICU DC SERVICE: GM, PICU, Endo, Genetics, ID, MOU, Neuro, Pulm, ENT	↓
SELECTED INTERVENTIONS (Low-End PICU; High-End IP Floor): CPAP, BiPAP, HFNC, Continuous Albuterol, Trach Collar	**493***

*Does not include patients who remained on an IP floor for their entire stay

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CY 2013: PICU Respiratory Admissions*

	Albuterol	HFNC	CPAP	BiPAP	Trach Collar
Asthma	45	20	5	38	0
Bronchiolitis	8	60	13	12	9
URI (NOS)	7	10	5	9	12
Pneumonia	3	24	8	33	12
Anaphylaxis	1	0	0	1	0
OSA/Tonsils	0	9	22	15	0
CF	0	1	0	24	0
Tracheitis	0	0	0	0	12
Resp/CLD	0	4	3	10	10
TOTAL	**64**	**128**	**56**	**141**	**55**

*Excluding ventilated patients

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CY 2013: PICU Respiratory Admissions

Month	Alb & PICU	HFNC	CPAP	BiPAP	Trach Collar	Total
1	3	19	6	19	5	52
2	4	15	4	8	8	39
3	5	12	5	10	9	41
4	8	9	7	10	7	41
5	11	9	7	24	6	57
6	6	5	2	5	6	24
7	3	3	4	5	4	19
8	4	6	2	7	12	31
9	8	9	9	16	6	48
10	4	14	5	19	10	52
11	5	13	4	17	7	46
12	3	17	5	14	10	49
Total	64	131	60	154	90	**499**
Avg. LOS (Hours)	75	131	109	163	130	**122**

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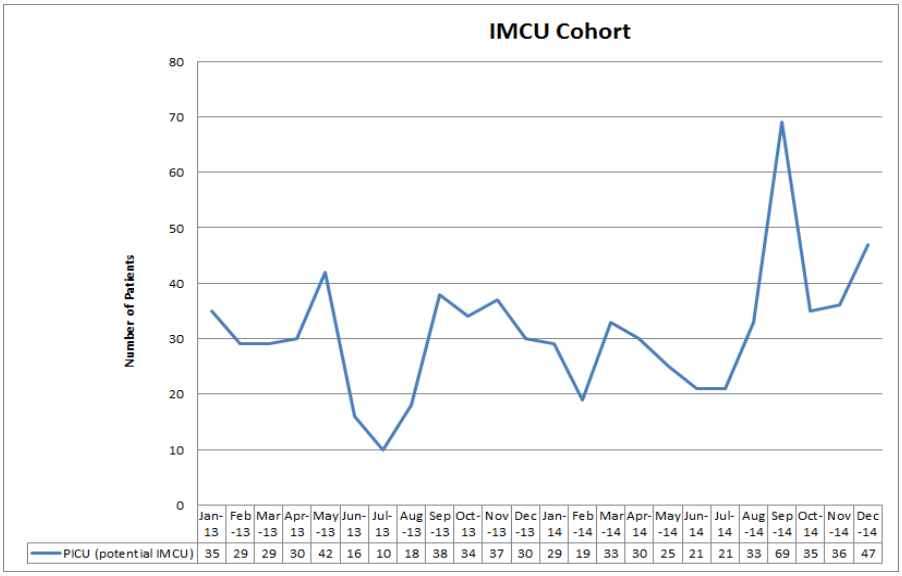
CY 2013-14 IMCU Cohort



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Finances: Seasonal Hospitalist Program

Staffing Costs	
HBM	$400K (2 FTEs)
TOTAL COST	**$400K**

Potential Revenue Enhancement / Losses	
Projected contribution margin lost by refusing 1-2 patients per week (24 cases)	**- $309K**
Projected revenue loss from moving 1-2 patients out of the PICU per week	- $202k
Projected revenue from functionally increasing PICU by 1-2 beds per week	+ $300k
TOTAL	**+$98K**

NOTES:
- Margin per case on Med-Surg patient $12,864
- Net differential between PICU and Med/Surg patients approx. $1,600 per day. Assumed 7 days ALOS
- Assumed 100% backfill of PICU beds.

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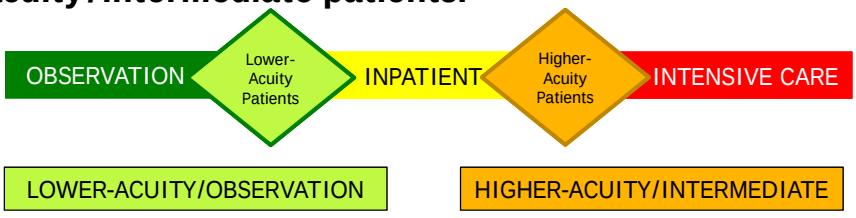
Seasonal Hospitalist Program

MISSION AND CARE MODEL

The Seasonal Hospitalist Program (SHoP) is an ~8 patient **service (with 24/7 in-house hospitalist coverage)** designed to address peak census issues and increased demand for access to ICU level care by promoting the safe and efficient care for two patient populations: **lower-acuity/observation & higher-acuity/intermediate patients.**



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Seasonal Hospitalist Program: Overview

Seasonal Hospitalist Program Data- March 2017	
Total Number of Admissions	**309**
SHoP Lower-Acuity Admissions	**198**
SHoP Higher-Acuity Admissions	**111**
PICU "Step-Down"	107
Vapotherm Admissions	68
PICU Bounce Backs	4
Floor "Step-Up"	4
Transfer to ICU	2
Additional Data	
Average discharge from unit time**	14:53
Average transfer from PICU to SHoP time	15:05
**44% of discharges before 14:00	
Census Implications	
Number of PICU RED ZONE (census =>38) **days** avoided **since SHoP Go-Live**	17
Number of PICU RED ZONE (census =>38) **nights** avoided **since SHoP Go-Live**	21

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Seasonal Hospitalist Program: Highlights

- Early AM discharges/transfers facilitated by 24/7 attending
- Higher-Acuity Patients quickly transitioned to floor level acuity
- Variable interpretation of "Higher-Acuity"
- "SHoP Unit" cohorting promotes safe care of High-Acuity patients
- Patients on HFNC can be safely taken care of outside of the PICU
- Twice daily huddles help with floor throughput and safety
- Multi-disciplinary teamwork is critical to the success of new initiatives

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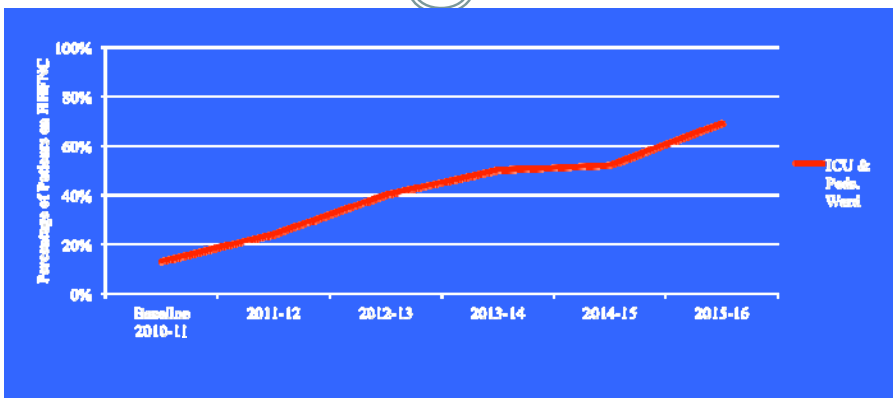
VINEETA MITTAL, MD MBA
ASSOCIATE PROFESSOR OF PEDIATRICS
UTSW MEDICAL CENTER AND CHILDREN'S HEALTH SYSTE, DALLAS, TX

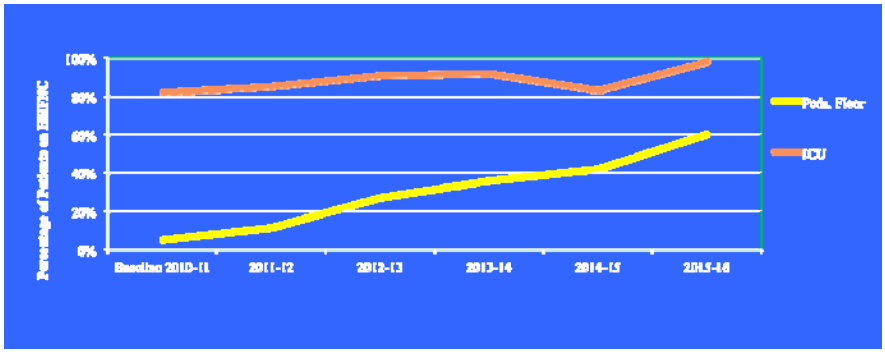
HFNC in University Affiliated Hospitals: Building Your Team Without Losing Your Mind!

Results: Trends in HFNC Use in Hospitalized Children



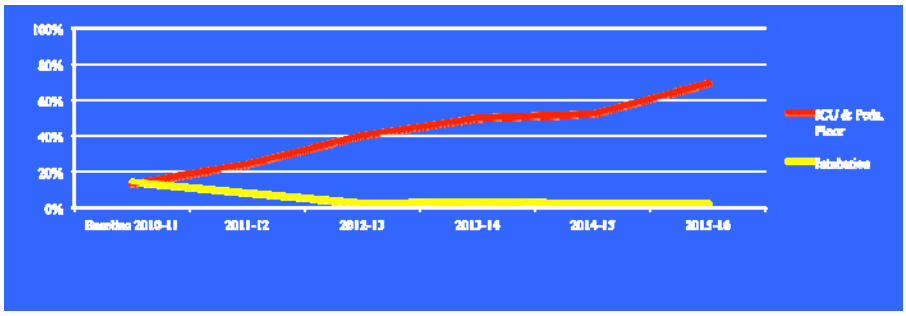
Baseline	2011-12	2012-13	2013-14	2014-15	2015-16	*P*
13%	24%	40%	50%	52%	69%	0.004

Results: Trends in HFNC Use Pediatric Wards and PICU

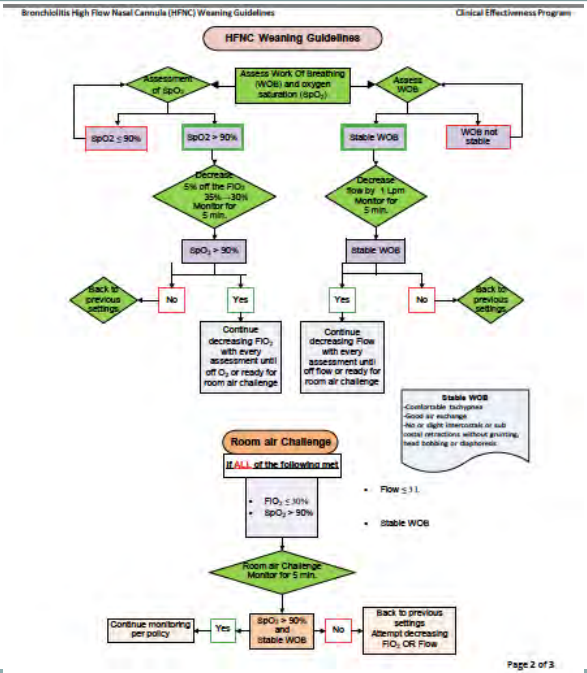


	Base	2011-12	2012-13	2013-14	2014-15	2015-16	*P*
Wards	5%	12%	27%	36%	42%	60%	<0.01
PICU	82%	85%	91%	92%	83%	98%	<0.001

Results: HFNC Use and Intubation Rate



	Base	2011-12	2012-13	2013-14	2014-15	2015-16	*P*
PICU & ward	13%	24%	40%	50%	52%	69%	0.004
Intubation rate	14%	8%	2%	3%	2%	2%	<0.0003



Panel Discussion

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Take Home Points

Questions/Comments?

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