A Patient-centered Framework for Health Systems Engineering in Gastroenterology

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Rationale of Improving Bowel Preparation

- Inpatient Colonoscopy Scheduled $\Rightarrow$ Bowel Prep Began
- What happens with *inadequate* bowel preps (clinically)?
  - Adverse Events (Almadi et al. 2018)
  - Delayed or Repeated Procedures (Ness 2001)
  - Negative Patient Outcome (Garber 2019)
- Improvement Goal: Medicine Alternation

Elements Impacting Bowel Prep Results

- Socioeconomic Status & Gender (Yadlapati et al. 2018)
- Age (Chung et al. 2009)
- Marriage Status (Lebwohl, Wang, and Neugut 2010)
- Complications:
  - Diabetes Mellitus (Reilly and Walker 2004)
  - Chronic Constipation (Hautefeuille et al. 2014)
  - Cirrhosis (Ness 2001)
- **Poor Compliance** (Almadi et al. 2018)

- Phase 1 Control before Medication Differences

Individualized Characteristics

Table: Characteristics of patients pre- and post-intervention to improve inpatient colonoscopy bowel preparation

	Pre-intervention (n=120)	Post-intervention (n=129)	p-value
Individual factors			
Age, mean (sd)	58.8 (17.34)	57.8 (17.5)	0.65
Male	61 (50.8)	63 (48.8)	0.75
Race, non-white	58 (48.3)	76 (58.9)	0.10
Primary team medicine service	113 (94.2)	113 (87.6)	0.07
Indication			0.85
Diarrhea, colitis	20 (16.7)	25 (19.4)	
Fecal transplant	1 (0.8)	3 (2.3)	
Abdominal pain	2 (1.7)	4 (3.1)	
Anemia	16 (13.3)	18 (14.0)	
Colon cancer	14 (11.7)	14 (10.9)	
Constipation	2 (1.7)	0	
Gastrointestinal bleeding	55 (45.8)	54 (41.9)	
Inflammatory bowel disease	10 (8.3)	11 (8.5)	
Systems factors			
Hourly inpatient occupancy, mean (range)	86.75 (85.61, 87.97)	90.32 (88.88, 90.88)	< 0.001

Data are presented as Number (%) unless otherwise noted
Sd: standard deviation

Initiated Protocol for Bowel Prep

GASTROENTEROLOGY INPATIENT BOWEL PREPARATION PROTOCOL

Gastroenterology Note Template

Place 2 orders for PEG-ELS: 4L (timed day prior to colonoscopy at 4 pm) and 2L (timed day of at 5 am)

Paste below into both orders and discuss plan with nurse:
1. Mix first dose of PEG-ELS with 4L of water
2. Patient should begin drinking the first dose of 4L between 4pm-6pm and finish within four hours of starting.
3. Patient should begin drinking the second dose of 2L at 5am and finish before 7am. (NPO at midnight except for preparation. Must finish by 7am or procedure may be cancelled due to aspiration risk)
4. When patient close to clear, nurse places hat in toilet. Once stool visualized as clear by nurse, primary team should be notified to confirm and update GI team.
5. If not clear by 7am, please inform GI team as patient may need 1-2L more prep. Do not give suppositories or enemas as this does not clear right side of colon.

Troubleshooting: If nausea, consider anti-emetics. Can chill the prep or substitute some of the 4L of water with non-red juice/sports drink. If patient unable to follow instructions of 1L/hr during time periods as above, consider NGT.

Education

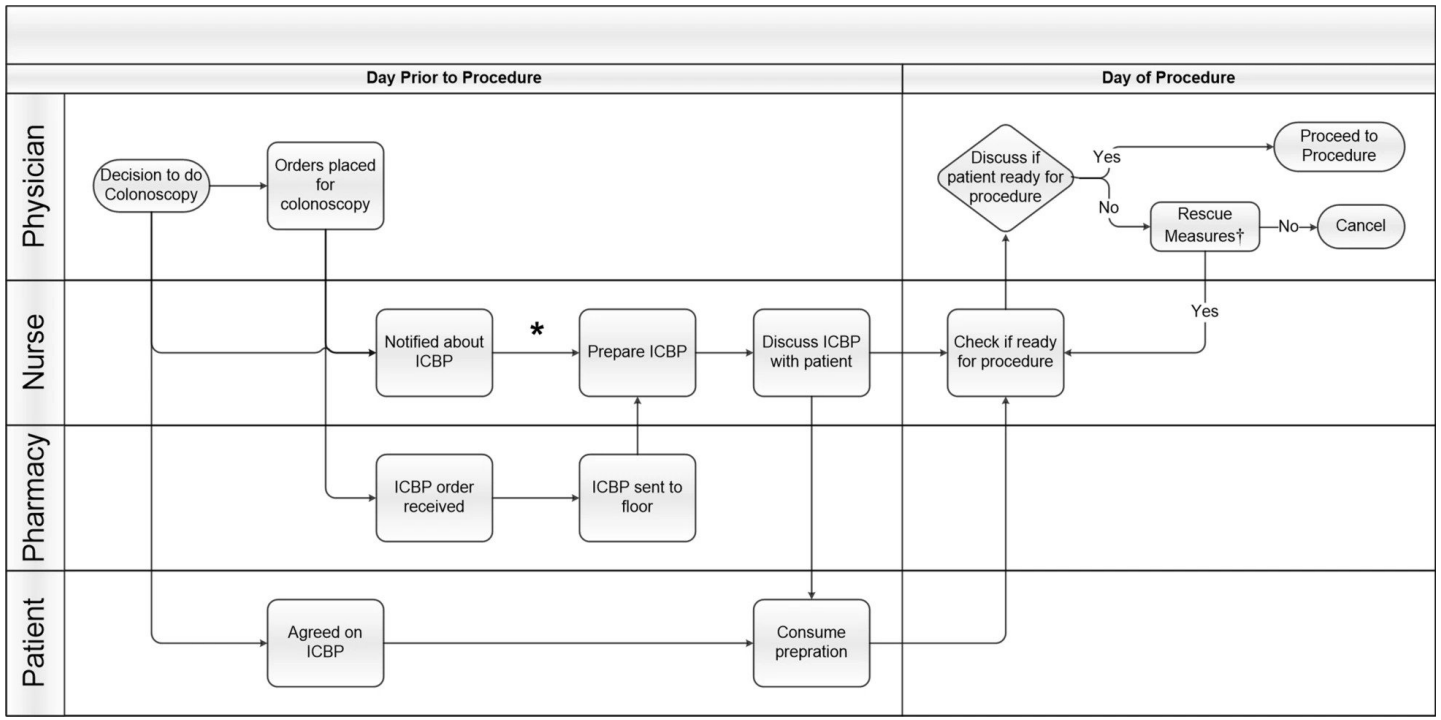
1. Patient
   - Handout
   - Verbal education
2. Nursing
   - Teaching at unit meetings
   - Point-of-care education
3. Primary Team
   - Resident education sessions
   - Point-of-care education
4. Fellow
   - BBPS flyers
   - Point-of-care education

Timeline

How the Medication Change Work

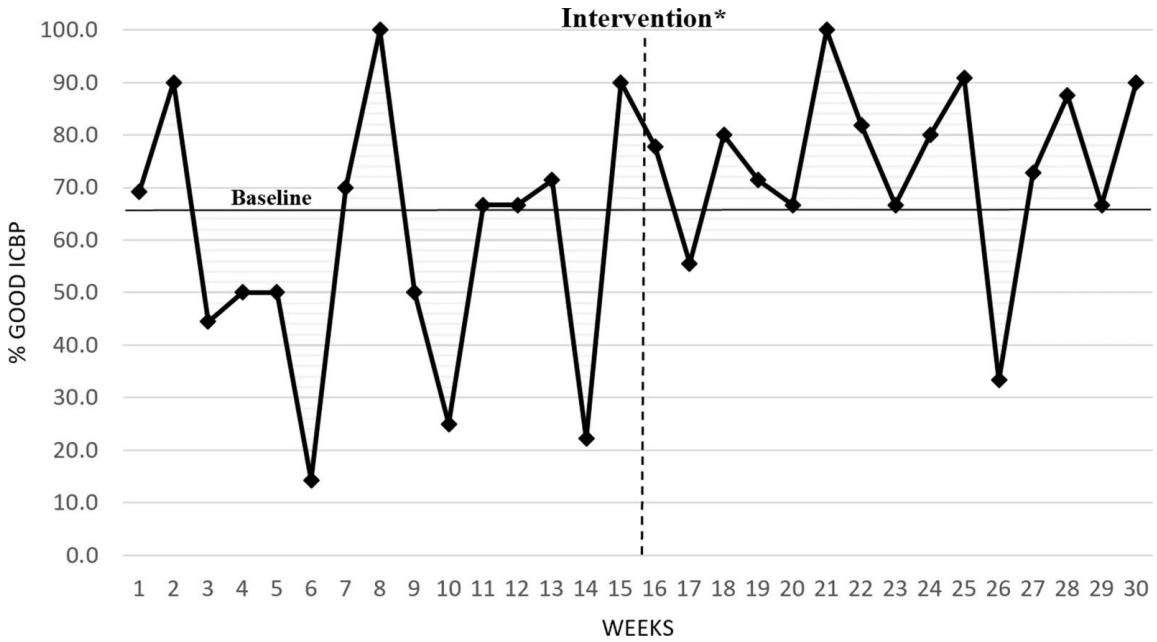
- Lower GI Bleed (Saltzman et al. 2015)
- Ref: American Society of Anesthesiologists Committee 2011
- Additional Requirement: **Patient Education** (Lai et al. 2009)
- The old way: one dose with 4-L of polyethylene glycol (PEG)
- Renewed method: 4-L + 2-L doses of glycol-electrolyte solution
  - Verbal Communication by 4 p.m. of the Decision
  - 4-L Dose between 4 p.m. and 6 p.m. Prior to Colonoscopy
  - 2-L Dose between 5 a.m. and 7 a.m. On the Colonoscopy Date

Workflow Identifying Medication Alteration



Runchart Capturing Preparation Score

- Boston Bowel Preparation Score (BBPS): Visibility by Radiology
- Creating Runcharts for Trending (Perla, Provost, and Murray 2011)



Study of Intervention and Analysis

- Good ICBP: Procedure delayed, but bowel prep successful
- Ideal ICBP: Procedure on time, and bowel prep successful

- Pre- and Post-Intervention: T-test, Wilcoxon Sum Rank Test
- Categorical Variables: Chi-square Test, Fisher's Exact Test
- Linear Splines for Time Estimates (Johnson et al. 2014)

Results of the Analysis

- Improvements on Both ICBP Status
- Improvements on Length of Stay

Table: Estimates from generalized linear model for adequate bowel preparations and length of stay before and after the intervention in unadjusted and adjusted models

Study Outcome	**Pre vs. Post**	**Unadjusted Model Relative Risk (Pre/Post) [95% Confidence Interval]**	**Adjusted Model Relative Risk (Pre/Post) [95% Confidence Interval]**
Good♯ ICBP	60.8% vs. 74.4%	1.873* [1.093,3.211]	1.947* [1.025,3.697]
Ideal‡ ICBP	53.3% vs. 69.0%	1.947* [1.160,3.266]	1.901* [1.024,3.531]
		Ratio of Means (Pre/Post) [95% Confidence Interval]	**Ratio of Means (Pre/Post) [95% Confidence Interval]**
Mean Length of Stay, Days	8 vs. 6	0.759 [0.538,1.069]	0.852 [0.617,1.179]

Adjusted model includes average weekly occupancy. ICBP: inpatient colonoscopy bowel preparations.
♯ Good: Colonoscopy delayed and adequate bowel preparation when performed.
‡ Ideal: Colonoscopy not delayed and adequate bowel preparation when performed. * $p<0.05$

Conclusion and Limitations

- This is only a single-center QI study with high patient volume
- Length of Stay estimation: multipliers & flow uncertainties

- Difficult to control certain comorbidities
- The unknown status we want to know: **Past Failed Bowel Preps**
- Compliance measurements (with qualitative input)

- Still, this is a piece of literature showing the necessity to alter golden-standard medication for bowel prep (PEG-GES)

Qualitative Input: Next Steps

Level	Potential problems	Potential solutions
Patient	Poor palatability	Switch to Polyethylene glycol-electrolyte solution with flavor packets of 4 flavors attached to bottle and no sulfur taste
		Chill bowel preparation
		Mix with flavor powders or non-red juice
	Unable to drink fast enough due to volume or nausea (assuming obstruction not suspected) or altered mental status (i.e. delirium or dementia)	Anti-emetics
		Nasogastric Tube
	Not following instructions	Patient education handout
		Family involvement
	Inpatient status ± underlying risk factors for poor bowel preparation	Consider 6-L bowel preparation
		Consider 2-day bowel preparation
	Flushes bowel movement before nurse evaluating	Nursing places toilet hat when close to ready
Nursing	Floor nurse protocol cannot require bedside checks more frequently than every 4 h	Encourage family to help
		Recruit medical assistant participation
		Use of technology for reminders
	Unclear importance of bowel preparation and instructions highly variable	Standardize instructions
		Nursing education sessions
		Endoscopy and floor nurses discuss day prior to procedure
	Original nurse communication with instructions acknowledged by day shift nurse and not viewed by night shift nurse	Instructions in medication order so viewable when administering
		Orderset with timed instructions
	Variable reporting of readiness for procedure	Nursing education and picture of readiness on patient education
		Toilet hat
		Endoscopy and floor nurses discuss morning of procedure
Physician	Preparation recommended by gastroenterology highly variable leading to confusion	Create protocol for standardization
	Instructions from gastroenterology not clear and/or written in notes	Electronic note templates for easy use in gastroenterology notes
	Due to nature of complex inpatient consult service, decision-to-scope communicated late (i.e., after 6 pm) to primary team	Set mutually agreed upon expectation for early communication by gastroenterology with a set latest time (i.e., 4 pm)
	Ordering suppositories and enemas as "rescue" in the morning leads to false sense patient is clear when right side of colon is not	Using more bowel preparation instead of suppositories and enemas
		Conversion to 2-day preparation
	Boston Bowel Preparation Score not properly documented. This could be knowledge gap or due to busy inpatient consult service while scoping. Procedure notes written at end of day leading to memory and bias	Scoring education
		Document score in Brief-Op note immediately post-procedure for reference later when writing procedure note
	Primary team orders differently than gastroenterology recommendations	Primary team education
		Orderset
System	Amount of bowel preparation consumed not documented	Fellow or nurse go to bedside to document amount drank
		Educate nursing day prior to document in medical record
	Lag time between order and administration	Stock bowel preparation in pyxis on specific floors
	Long chain of communication: GI, primary team, day nurse, night nurse	Set protocol for communication expectations, note templates, ordersets
	Dietary keeps flavor mix packs and nursing unable to get after certain hour	Stock flavor packs on floor or use Polyethylene glycol-electrolyte solution with flavor packets of 4 flavors attached to bottle