STA - 2016

Capnography reduces the risk of adverse outcomes during gastrointestinal endoscopic procedures with sedation administration

Background

Role of procedural sedation

- Patients often need to undergo painful, distressing, or unpleasant diagnostic and therapeutic procedures as part of their care [1]
- Beyond analgesia, sedation may be required to complete the procedure successfully and/or with minimal distress [1]
- Sedatives are used to induce a state on the patient that enables operative procedures without interfering with cardiorespiratory function
- The use of sedative/analgesia has been described in numerous guidelines [2-4]

[1] Atkinson P, et al. BMJ. 2014; 348. [2] Baker SN and Weant KA. J Pharm Prac2011;24:189-95.
[3] Godwin SA, et al. Ann Emerg Med. 2005;45:177-96. [4] Merchant R et al. Can J Anesth 2014; 61: 46-71

Growth of procedural sedation

- An analysis in the US identified that gastroenterology procedures using anesthesia increased from 14% in 2003 to over 30% in 2009 [1]
  - Although the number of procedures remained constant in Medicare patients, procedures using anesthesia increased from 13.5% to 30.2%
  - In privately insured patients, procedures increased by 51% and the use of anesthesia increased from 13.6% to 35.5%
- In Switzerland, the use of sedation in GI endoscopy increased from 60% in 1990 to 78% in 2003 [2]
- In Canada, >90% of patients receive sedation during colonoscopy [3]
- Use of sedation is now standard practice in Italy during gastrointestinal endoscopy [4]

[1] Liu H, et al. JAMA. 2012;307(11):1178-84. [2] Heuss LT, et al. Endoscopy. 2005;37:161-166.
[3] Porostocky P, et al. Can J Gastroenterol. 2011;25:255-260. [4] Fanti L, et al. Dig Liver Dis. 2011;43:726-730.

Important but Different Measurements

Capnography

- Measures $etCO_2$
- Reflects ventilation
- Hypoventilation & apnea are detected immediately
- During PSA, respiratory depression was 17.6 times more likely to be detected if monitored by capnography

*Waugh JB, Epps CA, Khodneva YA. Capnography enhances surveillance of respiratory events during procedural sedation: a meta-analysis. J Clin Anesth. 2011; 23(3):189-96.

Pulse Oximetry

- Measures SpO_2
- Reflects **oxygenation** level in the blood
- Values lag with hypoventilation & apnea
- Researchers found significant lag time (avg 3.7 minutes, up to 10 min) between $etCO_2$ abnormalities & SpO_2 desaturation*

* Langhan ML et al. Detection of Hypoventilation by Capnography. Pediatr Emer Care 2011;27: 394-397.

Value of Capnography ($etCO_2$)

- $etCO_2$ monitors adequacy of ventilation, SpO_2 monitors oxygenation
- Capnography is the earliest and only real-time measure of evolving respiratory compromise
- Waveform provides immediate indication of:
  - Hypoventilation
  - Airway obstruction
  - No breath
- Accurate 'physiologic' respiration rate

Does End Tidal CO2 Monitoring During Emergency Department Procedural Sedation and Analgesia With Propofol Decrease the Incidence of Hypoxic Events? A Randomized, Controlled Trial. Deitch K, Miner J, et al. Annals of Emergency Medicine. September 2009

Why is Capnography needed in Moderate – Deep Procedural Sedation?

Sedation is a continuum and patient response is unpredictable

	Minimal sedation (Anxiolysis)	Moderate sedation (Conscious Sedation)	Deep sedation / analgesia	General Anesthesia
Responsiveness	Normal response to verbal stimulation	Purposeful response to verbal or tactile stimulation	Purposeful response following repeated or painful stimulation	Unarousable, even with painful stimulus
Airway	Unaffected	No intervention required	Intervention may be required	Intervention often required
Spontaneous ventilation	Unaffected	Adequate	May be inadequate	Frequently inadequate
Cardiovascular function	Unaffected	Usually maintained	Usually maintained	May be impaired

Continuum of Depth of Sedation Definition of General Anesthesia and Levels of Sedation/Analgesia
(Approved by ASA House of Delegates on October 13, 1999, and amended on October 21, 2009)

Dangers of Moderate Sedation

- 100% of patients using propofol for colonoscopy dropped to 'general anesthesia' levels by brain monitoring.

  Brown et al. ASA 2006

- 70% of the patients required airway intervention during propofol sedation for colonoscopy.

  Ramsay et al. ASA 2006

- The proportion of claims for death was increased in claims outside the OR. Respiratory events were more common in remote location claims with inadequate oxygenation/ventilation the most common. 62% of claims due to oversedation were judged to be preventable by better monitoring.

  Metzner et al. Current Opinion in Anaesthesiology 2009, 22:502–508

- After overdose of sedative drug, respiratory depression was the most common specific damaging mechanism in MAC claims. Nearly half of these claims were judged as preventable by better monitoring, including capnography.

  Bhananker et al. Anesthesiology 2006; 104:228–34

Improving Outcomes in Procedural Sedation

- *The intention-to-treat analysis revealed a significant reduction of the incidence of oxygen desaturation in the capnography arm in comparison with the standard arm.*

  Beitz et al. American J of Gastroenterology 2012

- The results of this controlled effectiveness trial support routine use of [...] capnography to detect alveolar hypoventilation and reduce hypoxemia during procedural sedation in children.

  Lightdale et al. Pediatrics 2006

- During Procedural Sedation and Analgesia, cases of respiratory depression were 17.6 times more likely to be detected if monitored by capnography than cases not monitored by capnography.

  Meta-analysis, Waugh et al., J of Clinical Anesthesia 2011

Procedural Sedation

Standards for Moderate or Deep Sedation Procedural Sedation Practices-ASA Standards for Basic Anesthetic Monitoring (July, 2011)

Excerpt from 3.2.4- "During moderate or deep sedation the **adequacy of ventilation shall be evaluated** by continual observation of qualitative clinical signs **and monitoring for the presence of exhaled carbon dioxide** unless precluded or invalidated by the nature of the patient, procedure, or equipment."

ASA definition of 'Standard'- "Standards provide rules or **minimum requirements** for clinical practice. They are regarded as generally accepted principles of patient management. Standards may be modified only under unusual circumstances, e.g., extreme emergencies or unavailability of equipment."

Similar recommendations have also been passed by anesthesia societies in Canada, UK, and the European Society of Anesthesiology

Routine use of capnography for procedural sedation

- American Society of Anesthesiologists (ASA)
  - ASA Closed Claims project: 20 yrs of data revealed that over 60% of adverse events could have been prevented with improved monitoring
  - *Standards for Basic Anesthetic Monitoring* effective date of 7/1/2011

- 3.2.4 … During moderate or deep sedation the adequacy of ventilation shall be evaluated by continual observation of qualitative clinical signs and monitoring for the presence of exhaled carbon dioxide unless precluded or invalidated by the nature of the patient, procedure, or equipment.

Standards for Basic Anesthetic Monitoring ASA 10/20/2010

Routine use of capnography not yet recommended

- American Society for Gastrointestinal Endoscopy (ASGE) 2/2012 Statement:

  Universal adoption of capnography for moderate sedation in adults undergoing upper endoscopy and colonoscopy has not been shown to improve patient safety or clinical outcomes and significantly increases costs for moderate sedation.

Evaluating the Cost-Effectiveness of Capnography Monitoring in Procedural Sedation: A Gastroenterology (GI) Suite Cost-Avoidance Model

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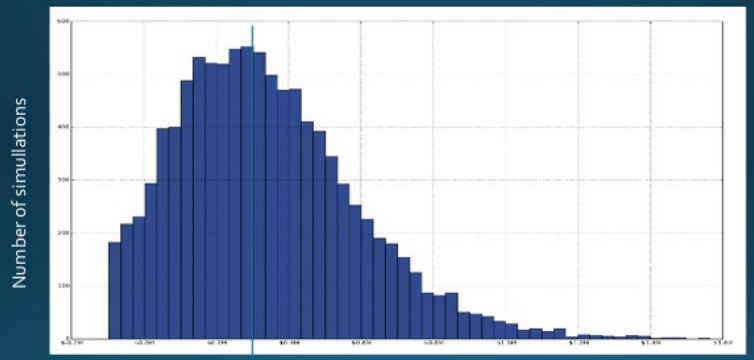
Monte Carlo Analysis

- 10,000 simulations
- Inputs
  - Reference hospital
  - Rates of adverse events
  - Costs of adverse events
  - Direct capnography cost assumptions
  - Capnography success rate

1 Year Cost Avoidance Distribution



Median cost avoidance with routine capnography
$304,234 in reference hospital

Conclusion

- The model demonstrates cost-effectiveness of routine capnography monitoring for GI procedural sedation
- Capnography represents an opportunity to improve patient safety and simultaneously decreasing overall facility costs

Capnography reduces the risk of adverse outcomes during gastrointestinal endoscopic procedures with sedation administration

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Disclaimer

- Following a rejection from an APSF grant application, I found that Covidien (now Medtronic) has access to the Premier Database and statisticians familiar with this type of research.
- Therefore this research was performed as a consultant with assistance from Medtronic

Methods

Premier Database:

- ~600 hospitals routinely submit data to Premier
- Complete hospital census (all patients, therapeutic classes, products / services used)
- HIPAA Compliant and undergoes rigorous quality checks
- Used by participating hospitals to benchmark clinical / financial performance
- FDA uses the Premier data for sentinel hospital surveillance
- 5.2+ million inpatient discharges per year
- 1 in 5 inpatient hospitalizations in the U.S.

Premier Database

Hospitals	526
Regions	
East North Central	16%
East South Central	6%
Middle Atlantic	11%
Mountain	5%
New England	4%
Pacific	15%
South Atlantic	26%
West North Central	7%
West South Central	10%
Teaching hospital	27%
Urban hospital	75%
<100 beds	20%
100-249 beds	34%
250-499 beds	34%
500+ beds	12%

Premier Database

- All hospital patients between 2008 and 2013
- Inpatients and outpatients
- Procedures:
  - esophagogastroduodenoscopy (EGD)
  - endoscopic retrograde cholangiopancreatography (ERCP)
  - colonoscopy
- Inclusion:
  - Sedative medication
- Exclusion:
  - Inhalation anesthetics (on procedure day)

Database results grouped:

- Pulse oximetry (SpO_2) only
- Capnography only
- SpO_2 and capnography
- Neither SpO_2 nor capnography

Database results grouped:

- Pulse oximetry (SpO_2) only → SpO_2
- Capnography only → Capnography
- SpO_2 and capnography → Capnography
- Neither SpO_2 nor capnography

Multivariate logistic regression analysis

- Age
- Gender
- Race
- Comorbid conditions
- Hospital characteristics

Propensity-score matching

- Propensity Score methodology was used to match patients (1:1 ratio) in Capnography sensor use to only a SpO_2 sensor used using age, gender, race, Comorbid conditions and Hospital characteristics
- Standard differences were calculated to measure how well the matched groups balanced

Key outcome measures

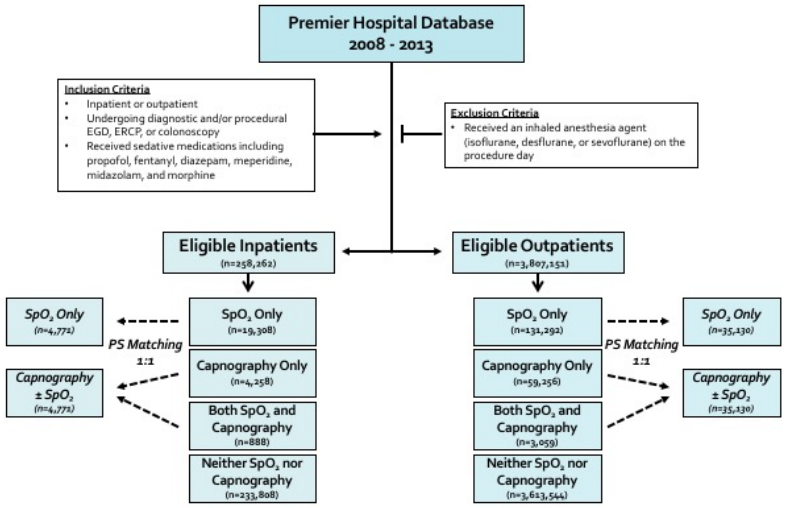
- Incidence of rescue events
  - Administration of naloxone and/or
  - Administration of flumazenil
- Incidence of death

Limitations

- Premier is a retrospective, administrative (billing) database
- Potential errors/biases
  - Coding error from the hospital end
  - Limited numbers of codes
- Retrospective review provides associations, not cause-and-effect

Results

- N= 4,065,413
  - Inpatients: 258,262
  - Outpatients: 3,807,151



Characteristic	Inpatient (n=258,262)				Outpatient (n=3,807,151)			
	SpO_2 Only (n=19,308)	Capnography Only (n=4,258)	SpO_2 and Capnography (n=888)	Neither (n=233,808)	SpO_2 Only (131,292)	Capnography Only (n=59,256)	SpO_2 and Capnography (n=3,059)	Neither (n=3,613,544)
Age	63.43 ± 18.42	64.12 ± 17.19	65.02 ± 17.05	64.33 ± 17.52	53.36 ± 20.91	58.35 ± 14.70	57.95 ± 15.24	57.54 ± 15.31
80+	3,961 (21%)	854 (20%)	204 (23%)	50,707 (22%)	8,260 (6%)	3,249 (5%)	183 (6%)	200,883 (6%)
71-80	3,886 (20%)	911 (21%)	168 (19%)	47,930 (21%)	18,818 (14%)	9,147 (15%)	458 (15%)	515,643 (14%)
61-70	3,733 (19%)	817 (19%)	181 (20%)	43,336 (19%)	27,376 (21%)	14,813 (25%)	729 (24%)	857,286 (24%)
51-60	3,399 (18%)	731 (17%)	158 (18%)	40,155 (17%)	30,363 (23%)	16,354 (28%)	792 (26%)	1,038,536 (28%)
41-50	2,193 (11%)	517 (12%)	105 (12%)	27,244 (12%)	17,515 (13%)	8,913 (15%)	520 (17%)	55,431 (15%)
31-40	1,039 (5%)	237 (6%)	48 (5%)	14,100 (6%)	8,924 (7%)	3,852 (7%)	223 (7%)	233,897 (6%)
18-30	752 (4%)	183 (4%)	17 (2%)	9,253 (4%)	6,412 (5%)	2,597 (4%)	119 (4%)	158,524 (4%)
< 18	345 (2%)	8 (0%)	7 (1%)	993 (0%)	13,624 (10%)	331 (1%)	35 (1%)	53,344 (1%)

Characteristic	Inpatient (n=258,262)				Outpatient (n=3,807,151)			
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CCI	2.59 ± 2.49	2.53 ± 2.48	2.57 ± 2.47	2.52 ± 2.46	0.51 ± 1.04	0.45 ± 0.97	0.79 ± 1.20	0.39 ± 0.90
>2	8,163 (42%)	1,743 (41%)	368 (41%)	95,025 (41%)	6,283 (5%)	2,310 (4%)	228 (7%)	119,647 (3%)
2	2,990 (15%)	637 (15%)	148 (17%)	36,636 (16%)	8,371 (6%)	3,302 (6%)	331 (11%)	171,185 (5%)
1	3,722 (19%)	894 (21%)	169 (19%)	43,112 (21%)	24,123 (18%)	10,705 (18%)	824 (27%)	571,858 (16%)
0	4,433 (23%)	984 (23%)	203 (23%)	53,035 (23%)	92,515 (70%)	42,939 (72%)	1,676 (55%)	2,750,854 (76%)
Gender								
Female	9,975 (52%)	2,224 (52%)	450 (51%)	124,726 (53%)	74,730 (57%)	33,635 (57%)	1,867 (61%)	2,024,108 (56%)
Male	9,333 (48%)	2,034 (48%)	438 (49%)	109,082 (47%)	56,562 (43%)	25,621 (43%)	1,192 (39%)	1,589,436 (44%)
Race								
White	14,032 (73%)	2,837 (67%)	580 (65%)	158,011 (68%)	101,037 (77%)	45,307 (76%)	2,689 (88%)	2,637,723 (73%)
Black	2,756 (14%)	731 (17%)	177 (20%)	34,632 (15%)	11,813 (9%)	6,380 (11%)	284 (9%)	304,535 (8%)
Hispanic	385 (2%)	77 (2%)	87 (10%)	7,084 (3%)	3,987 (3%)	1,234 (2%)	0 (0%)	66,752 (2%)
Other	2,135 (11%)	613 (14%)	44 (5%)	34,081 (15%)	14,455 (11%)	6,335 (11%)	86 (3%)	604,534 (17%)

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Comorbidity								
MI	1,713 (9%)	348 (8%)	72 (8%)	21,279 (9%)	2,171 (2%)	982 (2%)	115 (4%)	49,888 (1%)
CHF	3,688 (19%)	681 (16%)	148 (17%)	41,238 (18%)	2,281 (2%)	665 (1%)	113 (4%)	33,729 (1%)
Dementia	172 (1%)	24 (1%)	12 (1%)	2,127 (1%)	39 (<1%)	19 (<1%)	2 (<1%)	733 (<1%)
COPD	4,727 (25%)	1,031 (24%)	209 (24%)	55,507 (24%)	11,656 (9%)	4,524 (8%)	570 (19%)	254,671 (7%)
RA	657 (3%)	144 (3%)	26 (3%)	8,177 (4%)	1,453 (1%)	693 (1%)	60 (2%)	29,597 (1%)
PUD	2,748 (14%)	577 (14%)	98 (11%)	33,639 (14%)	5,453 (4%)	2,045 (4%)	162 (5%)	111,461 (3%)
Paralysis	172 (1%)	29 (1%)	7 (1%)	2,334 (1%)	91 (<1%)	23 (<1%)	6 (<1%)	1,459 (<1%)
CRF	4,070 (21%)	873 (21%)	183 (21%)	46,587 (20%)	1,638 (1%)	593 (1%)	63 (2%)	35,807 (1%)
Cancer	1,895 (10%)	449 (11%)	86 (10%)	23,155 (10%)	3,970 (3%)	1,611 (3%)	85 (3%)	85,219 (2%)
MST	916 (5%)	218 (5%)	50 (6%)	12,248 (5%)	496 (<1%)	190 (<1%)	13 (<1%)	9,539 (<1%)
AIDS	65 (<1%)	15 (<1%)	10 (1%)	978 (<1%)	72 (<1%)	27 (<1%)	2 (<1%)	1,687 (<1%)
Obesity	2,125 (11%)	461 (11%)	100 (11%)	25,189 (11%)	6,027 (5%)	1,644 (3%)	143 (5%)	130,982 (4%)
Diabetes	5,930 (31%)	1,354 (32%)	274 (31%)	71,495 (31%)	17,501 (13%)	7,797 (13%)	615 (20%)	393,796 (11%)
HTN	12,079 (63%)	2,747 (65%)	582 (66%)	144,259 (62%)	40,244 (31%)	18,788 (32%)	1,451 (47%)	972,692 (27%)
PVD	1,406 (7%)	281 (7%)	63 (7%)	15,224 (7%)	1,081 (1%)	340 (1%)	57 (2%)	17,958 (<1%)
CVD	1,303 (7%)	256 (6%)	54 (6%)	15,601 (7%)	764 (1%)	283 (<1%)	36 (1%)	11,995 (<1%)
MLD	2,021 (10%)	417 (10%)	98 (11%)	23,108 (10%)	1,913 (2%)	808 (1%)	63 (2%)	39,733 (1%)
MSLD	2,009 (10%)	399 (9%)	91 (10%)	22,687 (10%)	2,193 (2%)	917 (2%)	66 (2%)	43,521 (1%)

AIDS, acquired immune deficiency virus; APR, all patient refined; CCI, Charlson comorbidity index; CHF, congestive heart failure; COPD, chronic obstructive pulmonary disease; CRF, chronic renal failure; CVD, cardiovascular disease; HTN, hypertension; MI, myocardial infarction; MLD, mild liver disease; MSLD, moderate-severe liver disease; MST, metastatic solid tumor; PUD, peptic ulcer disease; PVD, peripheral vascular disease; RA, rheumatoid arthritis.

Characteristic	Inpatient (n=258,262)				Outpatient (n=3,807,151)			
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Region								
E. N. Central	707 (4%)	864 (20%)	19 (2%)	36,866 (16%)	900 (1%)	7,311 (12%)	30 (1%)	747,309 (21%)
E. S. Central	2,175 (11%)	7 (<1%)	41 (5%)	12,738 (5%)	22,514 (17%)	113 (<1%)	1,886 (62%)	218,449 (6%)
M. Atlantic	1,097 (6%)	12 (<1%)	0 (0%)	23,470 (10%)	148 (<1%)	8 (<1%)	0 (0%)	195,389 (5%)
Mountain	434 (2%)	370 (9%)	0 (0%)	11,684 (5%)	1,029 (1%)	2,959 (5%)	2 (<1%)	205,205 (6%)
New England	446 (2%)	108 (3%)	0 (0%)	8,113 (3%)	2,281 (2%)	7,431 (13%)	1 (<1%)	193,418 (5%)
Pacific	1,584 (8%)	380 (9%)	23 (3%)	34,221 (15%)	11,604 (9%)	3,170 (5%)	69 (2%)	572,954 (16%)
S. Atlantic	8,637 (45%)	2,122 (50%)	745 (84%)	67,627 (29%)	53,391 (41%)	31,137 (53%)	776 (25%)	884,648 (24%)
W. N. Central	603 (3%)	80 (2%)	8 (1%)	16,276 (7%)	8,190 (6%)	355 (1%)	7 (<1%)	370,834 (10%)
W. S. Central	3,625 (19%)	315 (7%)	52 (6%)	22,813 (10%)	31,235 (24%)	6,772 (11%)	288 (9%)	225,338 (6%)
Teaching Hospital	8,672 (45%)	804 (19%)	130 (15%)	88,195 (38%)	41,105 (31%)	9,659 (16%)	491 (16%)	1,117,242 (31%)
Hospital Bed size								
< 250	2,523 (13%)	822 (19%)	81 (9%)	52,543 (22%)	38,376 (29%)	17,738 (30%)	1,968 (64%)	1,303,833 (36%)
250 - 500	7,752 (40%)	2,571 (60%)	257 (29%)	112,743 (48%)	25,602 (20%)	33,685 (57%)	1,022 (33%)	1,672,591 (46%)
500 +	9,033 (47%)	865 (20%)	550 (62%)	68,522 (29%)	67,314 (51%)	7,833 (13%)	69 (2%)	637,120 (18%)
Hospital Location								
Rural	2,320 (12%)	1,124 (26%)	47 (5%)	26,096 (11%)	27,118 (21%)	8,926 (15%)	44 (2%)	598,635 (17%)
Urban	16,988 (88%)	3,334 (74%)	841 (95%)	207,712 (89%)	104,174 (79%)	50,340 (85%)	3,015 (99%)	3,014,909 (83%)

PS Matching – Inpatient Population

Characteristics	Before Match			After Match		
	Capnography ± SpO_2 (n=5,146)	SpO_2 Only (n=19,308)	Standard Difference	Capnography ± SpO_2 (n=4,772)	SpO_2 Only (n=4,771)	Standard Difference
Age (mean)	64.27	63.43	0.047	64.12	63.90	0.012
CCI (mean)	2.53	2.59	-0.021	2.55	2.51	0.019
Male	48.04%	48.34%	-0.006	47.66%	49.49%	-0.036
Race						
White	66.40%	72.67%	**-0.237**	65.44%	66.52%	-0.023
Black	17.64%	14.27%	0.092	18.05%	15.64%	0.064
Hispanic	3.19%	1.99%	0.075	3.21%	3.31%	-0.006
Other	12.77%	11.06%	0.053	13.31%	14.55%	-0.036
APR severity of illness						
1=mild	10.30%	9.07%	0.042	10.21%	10.21%	0.000
2=moderate	33.66%	29.11%	0.098	32.53%	32.78%	-0.005
3=severe	42.29%	42.90%	-0.012	42.65%	41.48%	0.024
4=extreme	13.76%	18.92%	**-0.140**	14.61%	15.53%	-0.026
Region						
South	63.78%	74.77%	**-0.240**	68.77%	68.12%	0.014
Northeast	2.33%	7.99%	**-0.258**	2.52%	2.22%	0.019
Midwest	18.87%	6.79%	**0.367**	12.89%	15.18%	-0.066
West	15.02%	10.45%	**0.137**	15.83%	14.48%	0.037
Teaching hospital	18.15%	44.91%	**-0.601**	19.56%	20.35%	-0.020
Hospital Bed size						
< 250	17.55%	13.07%	**0.125**	18.53%	19.51%	-0.025
250 - 500	54.96%	40.15%	**0.300**	51.86%	50.51%	0.027
500 +	27.50%	46.78%	**-0.407**	29.62%	29.97%	-0.008
Hospital Location						
Urban	77.24%	87.98%	**-0.286**	81.97%	82.23%	-0.007

PS Matching – Inpatient Population

Characteristics	Before Match			After Match		
	Capnography ± SpO_2 (n=5,146)	SpO_2 Only (n=19,308)	Standard Difference	Capnography ± SpO_2 (n=4,772)	SpO_2 Only (n=4,771)	Standard Difference
Comorbidity						
MI	8.16%	8.87%	-0.025	8.30%	8.38%	-0.003
CHF	16.11%	19.10%	-0.079	16.20%	16.77%	-0.015
Dementia	0.70%	0.89%	-0.022	0.75%	0.80%	-0.005
COPD	24.10%	24.48%	-0.009	24.25%	24.02%	0.006
RA	3.11%	3.40%	-0.017	3.16%	3.08%	0.005
PUD	13.32%	14.23%	-0.032	13.37%	13.92%	-0.016
Paralysis	0.70%	0.89%	-0.022	0.75%	0.67%	0.010
CRF	20.52%	21.08%	-0.014	20.75%	20.50%	0.006
Cancer	10.40%	9.82%	0.019	10.42%	10.17%	0.008
MST	5.21%	4.74%	0.021	5.20%	4.63%	0.026
AIDS	0.49%	0.34%	0.023	0.44%	0.42%	0.003
Obesity	10.90%	11.01%	-0.003	11.09%	10.98%	0.003
Diabetes	31.64%	30.71%	0.020	31.78%	30.62%	0.025
HTN	64.69%	62.56%	0.044	64.83%	63.36%	0.031
PVD	6.69%	7.28%	-0.023	6.77%	6.96%	-0.007
CVD	6.02%	6.75%	-0.030	6.06%	6.25%	-0.008
MLD	10.01%	10.42%	-0.013	10.23%	10.19%	0.001
MSLD	9.52%	10.41%	-0.029	9.77%	9.87%	-0.004

AIDS, acquired immune deficiency virus; APR, all patient refined; CCI, Charlson comorbidity index; CHF, congestive heart failure; COPD, chronic obstructive pulmonary disease; CRF, chronic renal failure; CVD, cardiovascular disease; HTN, hypertension; MI, myocardial infarction; MLD, mild liver disease; MSLD, moderate-severe liver disease; MST, metastatic solid tumor; PUD, peptic ulcer disease; PVD, peripheral vascular disease; RA, rheumatoid arthritis.

PS Matching – Outpatient Population

Characteristics	Before Match			After Match		
	Capnography ± SpO_2 (n=62,315)	SpO_2 Only (n=131,292)	Standard Difference	Capnography ± SpO_2 (n=35,130)	SpO_2 Only (n=35,130)	Standard Difference
Age (mean)	58.33	53.36	**0.275**	56.70	57.81	-0.060
CCI (mean)	0.47	0.51	-0.038	0.58	0.62	-0.031
Male	43.03%	43.08%	-0.001	42.47%	42.37%	0.001
Race						
White	77.02%	76.96%	0.002	73.40%	77.45%	-0.094
Black	10.69%	9.06%	0.057	10.01%	10.11%	-0.004
Hispanic	1.98%	3.04%	-0.068	3.39%	2.69%	0.041
Other	10.30%	11.01%	-0.023	13.21%	9.75%	**0.109**
Region						
South	65.75%	81.60%	**-0.366**	79.78%	82.66%	-0.074
Northeast	11.94%	1.85%	**0.406**	0.73%	1.42%	-0.067
Midwest	12.36%	6.92%	**0.185**	3.50%	2.97%	0.030
West	9.95%	9.62%	0.011	16.00%	12.95%	0.087
Teaching hospital	16.29%	31.31%	**-0.358**	24.56%	25.72%	-0.027
Hospital Bed size						
< 250	31.62%	29.23%	0.052	34.18%	37.23%	-0.064
250 - 500	55.70%	19.50%	**0.806**	43.33%	41.02%	0.047
500 +	12.68%	51.27%	**-0.909**	22.49%	21.75%	0.017
Hospital Location						
Urban	85.62%	79.35%	**0.166**	85.96%	87.44%	-0.044

PS Matching – Outpatient Population

Characteristics	Before Match			After Match		
	Capnography ± SpO_2 (n=62,315)	SpO_2 Only (n=131,292)	Standard Difference	Capnography ± SpO_2 (n=35,130)	SpO_2 Only (n=35,130)	Standard Difference
Comorbidity						
MI	1.76%	1.65%	0.008	2.09%	2.11%	-0.001
CHF	1.25%	1.74%	-0.040	1.97%	2.08%	-0.008
Dementia	0.03%	0.03%	0.002	0.05%	0.04%	0.007
COPD	8.17%	8.88%	**-0.252**	10.39%	11.56%	-0.037
RA	1.21%	1.11%	0.010	1.31%	1.32%	0.000
PUD	3.54%	4.15%	-0.032	4.45%	4.82%	-0.018
Paralysis	0.05%	0.07%	-0.009	0.08%	0.08%	-0.001
CRF	1.05%	1.26%	-0.020	1.51%	1.73%	-0.018
Cancer	2.72%	3.02%	-0.018	3.61%	3.52%	0.005
MST	0.33%	0.38%	-0.009	0.47%	0.50%	-0.004
AIDS	0.05%	0.05%	-0.004	0.06%	0.05%	0.007
Obesity	2.87%	4.59%	-0.091	4.45%	5.29%	-0.039
Diabetes	13.50%	13.33%	0.005	15.27%	15.44%	-0.005
HTN	32.48%	30.65%	0.039	35.19%	34.79%	0.008
PVD	0.64%	0.82%	**-0.219**	0.95%	1.02%	-0.007
CVD	0.35%	0.58%	**-0.338**	0.58%	0.72%	-0.017
MLD	1.40%	1.46%	-0.005	1.63%	1.79%	-0.013
MSLD	1.58%	1.67%	-0.007	1.83%	2.11%	-0.020

AIDS, acquired immune deficiency virus; APR, all patient refined; CCI, Charlson comorbidity index; CHF, congestive heart failure; COPD, chronic obstructive pulmonary disease; CRF, chronic renal failure; CVD, cardiovascular disease; HTN, hypertension; MI, myocardial infarction; MLD, mild liver disease; MSLD, moderate-severe liver disease; MST, metastatic solid tumor; PUD, peptic ulcer disease; PVD, peripheral vascular disease; RA, rheumatoid arthritis.

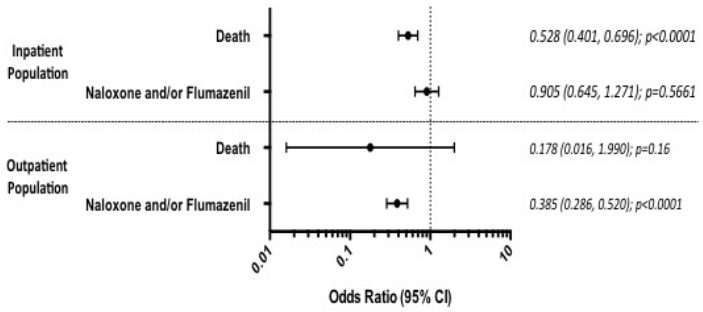
Table : Inpatient Outcomes Before and After Match

	Capnography Sensor +/- SpO_2 Sensor	SpO_2 Sensor Only	p-value
	Before Match		
Death	100 (1.94%)	792 (4.12%)	<0.0001
Rescue event	69 (1.34%)	325 (1.68%)	0.08
	After Match		
Death	94 (1.97%)	166 (3.48%)	<0.0001
Rescue event	66 (1.38%)	74 (1.55%)	0.50

Table : Outpatient Outcomes Before and After Match

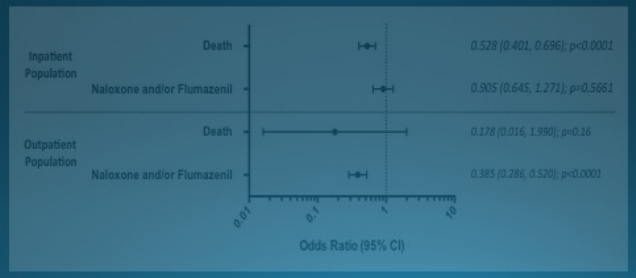
	Capnography Sensor +/- SpO_2 Sensor	SpO_2 Sensor Only	p-value
	Before Match		
Death	1 (0.00%)	10 (0.01%)	0.12
Rescue event	129 (0.21%)	466 (0.35%)	<0.0001
	After Match		
Death	1(0.00%)	4 (0.01%)	0.38
Rescue event	63(0.18%)	148 (0.42%)	<0.0001

Multivariate Logistic Regression using PS Matched Samples



Conclusions

- In hospital inpatients and outpatients undergoing gastrointestinal endoscopic procedures performed with sedation administration, capnography sensor use was associated with a reduced likelihood of rescue events and death.
- The use of capnography in these procedures is warranted.

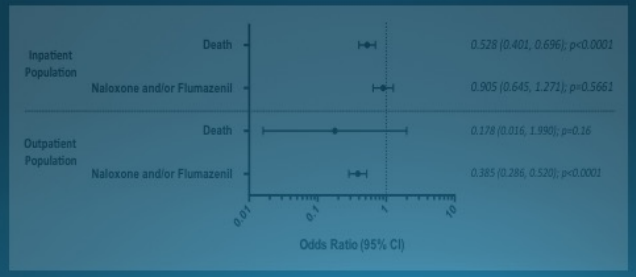


Routine use of capnography not yet recommended

- American Society for Gastrointestinal Endoscopy (ASGE) 2/2012 Statement:

  Universal adoption of capnography for moderate sedation in adults undergoing upper endoscopy and colonoscopy has not been shown to improve patient safety or clinical outcomes and significantly increases costs for moderate sedation.

- In hospital inpatients and outpatients undergoing gastrointestinal endoscopic procedures performed with sedation administration, capnography sensor use was associated with a reduced likelihood of rescue events and death.
- The use of capnography in these procedures is warranted.



Questions