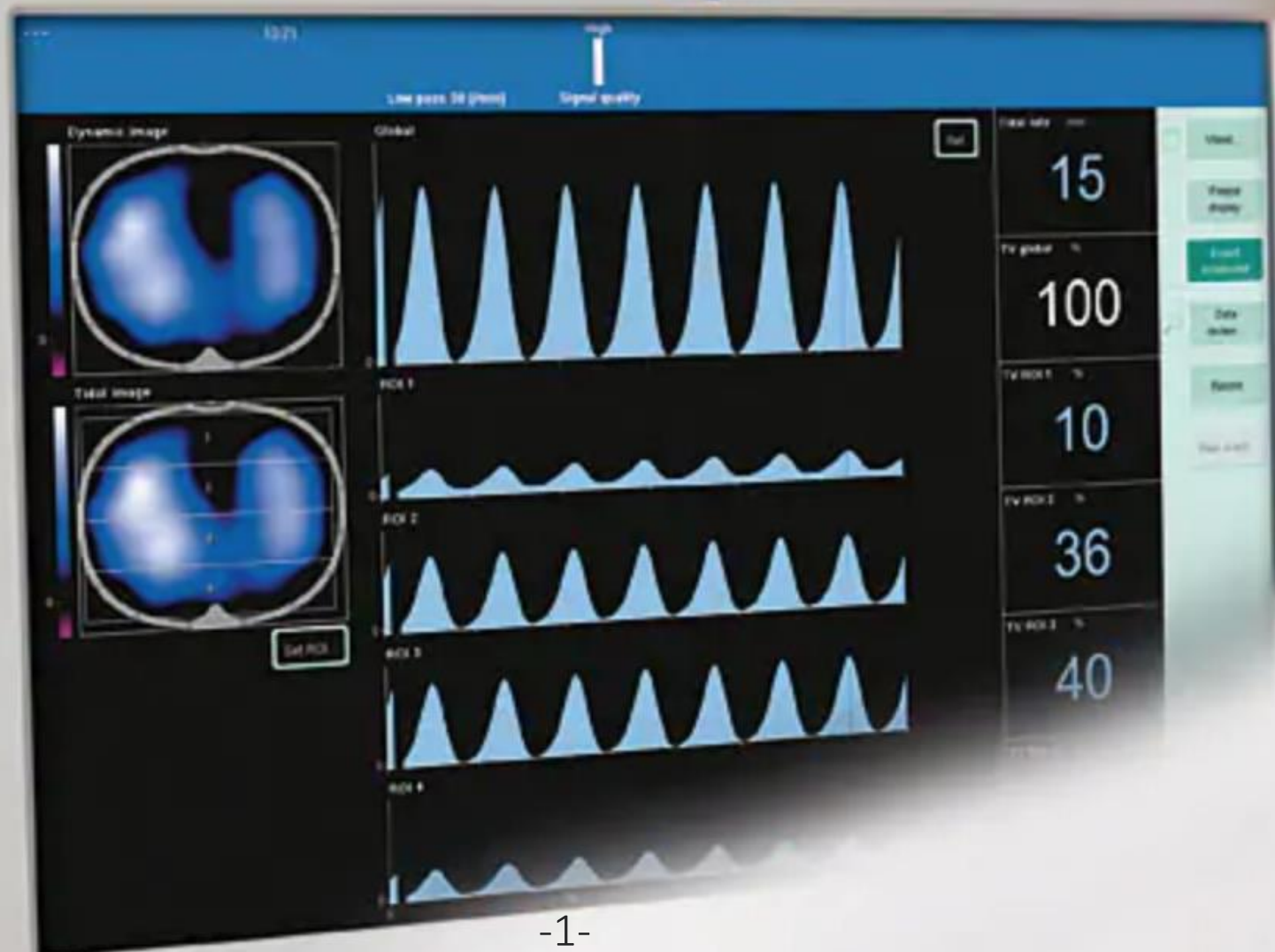


Visible Ventilation

Elektrische Impedantie Tomografie (E.I.T.) in het weantraject

Mascha de Groot, Ventilation Practitioner i.o.
Intensive Care Centrum, Medisch Spectrum Twente
30 Oktober 2019

Dräger



Inhoud

- Inleiding: Medisch Spectrum Twente (MST) & het Intensive Care Centrum (ICC)
- Aanleiding
- Onderzoek
 - Ontwennen, E.I.T. & literatuur
 - Onderzoeksopzet, doel- en vraagstelling, setting
 - In- & exclusie-criteria
 - Methodiek
 - Statistische analyse en resultaten
- Conclusie en aanbevelingen
- Rol Ventilation Practitioner

Geschiedenis



2008: Intensive Care in leger-units.

MST sinds 2016



- Topklinisch
- Traumacentrum
- 620 bedden



- Neuro- en cardiothoracale-chirurgie, hematologie
- Verzorgingsgebied 264.000 personen
- Zeer diverse patiëntenpopulatie



Intensive Care Centrum



- 3 units
 - 32 bedden waarvan 30 beademingsbedden
 - 6500 beademingsdagen/ jaar
-
- 120 Intensive Care verpleegkundigen
 - 10 Medium Care verpleegkundigen
 - 5 Ventilation Practitioners (2 i.o.)
 - 2 Renal Practitioners



Aanleiding

- Pulmovista™ sinds 2016 op onze afdeling
- Twee verschillende methoden voor het uitvoeren van een Spontaneous Breathing Trial, geen bewijs voor superioriteit van een methode
- Eerder onderzoek door Bickenbach



RESEARCH

Open Access



Electrical impedance tomography for predicting failure of spontaneous breathing trials in patients with prolonged weaning

Johannes Bickenbach^{1††}, Michael Czaplík^{2†}, Mareike Polier¹, Gernot Marx¹, Nikolaus Marx³ and Michael Dreher³

Abstract

Background: Spontaneous breathing trials (SBTs) on a T-piece can be difficult in patients with prolonged weaning because of remaining de-recruitment phenomena and/or insufficient ventilation. There is no clinically established method existent other than experience for estimating whether an SBT is most probably beneficial. Electrical impedance tomography (EIT) is a clinical useful online monitoring technique during mechanical ventilation, particularly because it enables analysis of effects of regional ventilation distribution. The aim of our observational study was to examine if EIT can predict whether patients with prolonged weaning will benefit from a planned SBT.

Methods: Thirty-one patients were examined. Blood gas analysis, vital parameter measurements, and EIT recordings were performed at three time points: (1) baseline with pressure support ventilation (PSV) (t0), (2) during a T-piece trial (t1), and (3) after resumption of PSV (t2). Calculation of EIT parameters was performed, including the impedance ratio (IR), the tidal variation of impedance (TIV), the changes in end-expiratory lung impedance ($\Delta EELI$), the global inhomogeneity index (GI), and the regional ventilation delay (RVD) index with use of different thresholds of the percentage inspiration time (RVD40, RVD60, RVD80). The predictive power of the baseline GI with regard to clinical impairment of an SBT was analyzed by means of ROC curves. Clinical deterioration was assumed when tidal volume was decreased by at least 20 ml after the T-piece trial, measured at t2.

Results: Partial pressure of arterial oxygen significantly decreased at t1 (71 ± 15 mmHg) compared with t0 (85 ± 17 mmHg, $p < 0.05$) and t2 (82 ± 18 mmHg, $p < 0.05$). The IR trended toward higher values during t1. At t1, TIV and $\Delta EELI$ significantly decreased. The GI was significantly increased at t1 (t0 59.3 ± 46.1 vs t1 81.5 ± 62.5 , $p = 0.001$), as were all RVD indexes. Assuming a GI cutoff value of >40 , sensitivity of 85% and specificity of 50% were reached for predicting an increased future tidal volume.

Conclusions: EIT enables monitoring of regional ventilation distribution during SBTs and is suitable to estimate whether an SBT probably will be beneficial for an individual patient. Therefore, the application of EIT can support clinical decisions regarding patients in the phase of prolonged weaning.

Keywords: Mechanical ventilation, Ventilatory heterogeneity, Electrical impedance, Tomography, Prolonged weaning

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Ontwennen van beademing

- Ontwennen: 40-50% van de gehele beademingsduur
- Spontaneous Breathing Trial (SBT)
- Methoden binnen MST:
 - Minimale ondersteuning middels beademing
 - High flow zuurstof / Optiflow™ op tube of canule

Literatuur

Stripoli et al. *Ann. Intensive Care* (2019) 9:4
https://doi.org/10.1186/s13613-019-0482-2

Annals of Intensive Care

RESEARCH

High-flow oxygen therapy in tracheostomized patients of weaning failure

Tania Stripoli^{1†}, Savino Spadaro^{2†}, Rosa Di Mussi¹, Carlo Al Rachele Iannuzziello¹, Fabio Sechi³, Paola Pierucci⁴, Francesco Salvatore Grasso^{1*}

Abstract

Purpose: High-flow oxygen therapy delivered through nasal cannula in critically ill patients. Little is known of the physiology of breathing in critically ill patients. In this study, we compared high-flow oxygen therapy (conventional O₂) on neuro-ventilatory drive, work of breathing, and arterial blood gases.

Methods: This was a single-center, unblinded, cross-over study. The inspiratory oxygen fraction was titrated to achieve an arterial oxygen saturation of 90–95%. The inspiratory oxygen fraction was titrated to achieve an arterial oxygen saturation of 90–95%. We recorded neuro-ventilatory drive (electrical diaphragm pressure–time product per breath and per minute), and arterial blood gases.

Results: The EAdi_{peak} remained unchanged (mean ± SD) in the 8.8 ± 4.3 μV vs 8.9 ± 4.8 μV vs 9.0 ± 4.1 μV, respectively, $p = 0.05$, exchange remained unchanged.

Conclusions: In tracheostomized patients at high risk of weaning, high-flow oxygen therapy, work of breathing, respiratory O₂ after disconnection from the ventilator. The present findings suggest that high-flow oxygen therapy through tracheostomy substantially differ from nasal cannula.

Keywords: High-flow oxygen therapy, Tracheostomy, Weaning, Work of breathing

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[†]Tania Stripoli and Savino Spadaro must be both deemed as first authors

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Mitaka et al. *Journal of Medical Case Reports* (2018) 12:292
https://doi.org/10.1186/s13256-018-1832-7

Journal of
Medical Case Reports

CASE REPORT

Open Access

High-flow oxygen via tracheostomy facilitates weaning from prolonged mechanical ventilation in patients with restrictive pulmonary dysfunction: two case reports

Chieko Mitaka^{1*}, Masahiko Odoh¹, Daizoh Satoh¹, Tadasuke Hashiguchi² and Eiichi Inada¹

Abstract

Background: Weaning from prolonged mechanical ventilation is extremely difficult in tracheostomized patients with restrictive pulmonary dysfunction. High-flow oxygen via tracheostomy supplies heated and humidified oxygen gas at > 10 L/minute. However, little has been reported on the use of high-flow oxygen via tracheostomy during weaning from ventilators in patients with restrictive pulmonary dysfunction. We report successful weaning from ventilators in patients with restrictive pulmonary dysfunction using high-flow oxygen via tracheostomy.

Case presentation: The first patient is a 78-year-old Japanese man with severe pneumococcal pneumonia who was mechanically ventilated for more than 1 month after esophagectomy for esophageal cancer. After he underwent tracheostomy because of prolonged mechanical ventilation, restrictive pulmonary dysfunction appeared: tidal volume 230–240 mL and static compliance 14–15 mL/cmH₂O with 10 cmH₂O pressure support ventilation. He was weaned from the ventilator under inspiratory support with high-flow oxygen via tracheostomy over a period of 16 days (flow at 40 L/minute and fraction of inspired oxygen of 0.25). The second patient is a 69-year-old Japanese man who developed aspiration pneumonia after esophagectomy and received prolonged mechanical ventilation via tracheostomy. He developed restrictive pulmonary dysfunction. High-flow oxygen via tracheostomy (flow at 40 L/minute with fraction of inspired oxygen of 0.25) was administered with measurement of the airway pressure and at the entrance of the tracheostomy tube. The measured values were as follows: 0.21–0.3 cmH₂O, 0.21–0.56 cmH₂O, 0.54–0.91 cmH₂O, 0.76–2.01 cmH₂O, 1.17–2.01 cmH₂O, and 1.76–2.01 cmH₂O at 10 L/minute, 20 L/minute, 30 L/minute, 40 L/minute, 50 L/minute, and 60 L/minute, respectively. The airway pressures were continuously positive and did not become negative even during inspiration, suggesting that high-flow oxygen via tracheostomy reduces inspiratory effort. He was weaned from the ventilator under inspiratory support with high-flow oxygen via tracheostomy over a period of 12 days.

Conclusions: High-flow oxygen via tracheostomy may reduce the inspiratory effort and enhance tidal volume by delivering high-flow oxygen and facilitate weaning from prolonged mechanical ventilation in patients with restrictive pulmonary dysfunction.

Keywords: High-flow oxygen, Hypercapnia, Restrictive pulmonary dysfunction, Tracheostomy, Weaning

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Key: YYYY; NN(0): pp-pp



and Spontaneous Breathing Trials; an

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Received: February 2016; Accepted: March 2016

describe the gradual process of decreasing ventilator support. It is estimated that alveolar ventilation is dedicated to the process of weaning. Spontaneous breathing ability to breathe while receiving minimal or no ventilator support. The collection of the process of SBT and weaning should start by assessing whether the underlying condition has been resolved or not. Weaning predictors are parameters that are intended to predict weaning attempts will be successful or not. Although the international consensus recommends their routine use for clinical decision making, researchers did not present article, we review some of the recent studies about weaning predictors, assessment for extubation a mechanically ventilated patient.

Shahid Beheshti University of Medical Sciences

Safari S. Ventilator Weaning and Spontaneous Breathing Trials; an Educational Review

jective criteria is usually used to determine disease reversal. Usually the criteria used are improvement of gas exchange, improvement of mental status, neuromuscular functional assessment and radiographic signs (7). However, it should be kept in mind that some patients who do not meet these criteria are eventually successfully weaned (8). Weaning predictors are parameters that are intended to help clinicians predict whether weaning attempts will be successful or not. Although the international consensus conference in 2005 did not recommend their routine use for clinical decision making, researchers did not stop working in this area (9). In the present article, we review some of the recent studies about weaning predictors, criteria, procedure, as well as assessment for extubation a mechanically ventilated patient.

2. Weaning predictors

2.1. Heart rate variability

The process of weaning leads to changes in the hemodynamic and autonomic nervous systems. Two prospective observational studies showed that reduced heart rate variability during spontaneous breathing trials (SBT) was significantly associated with extubation failure (10–12). Arentales et al.

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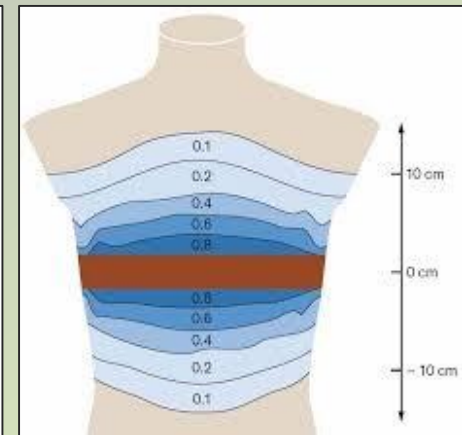
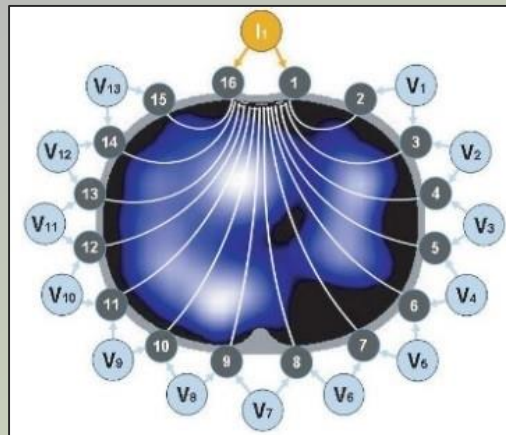
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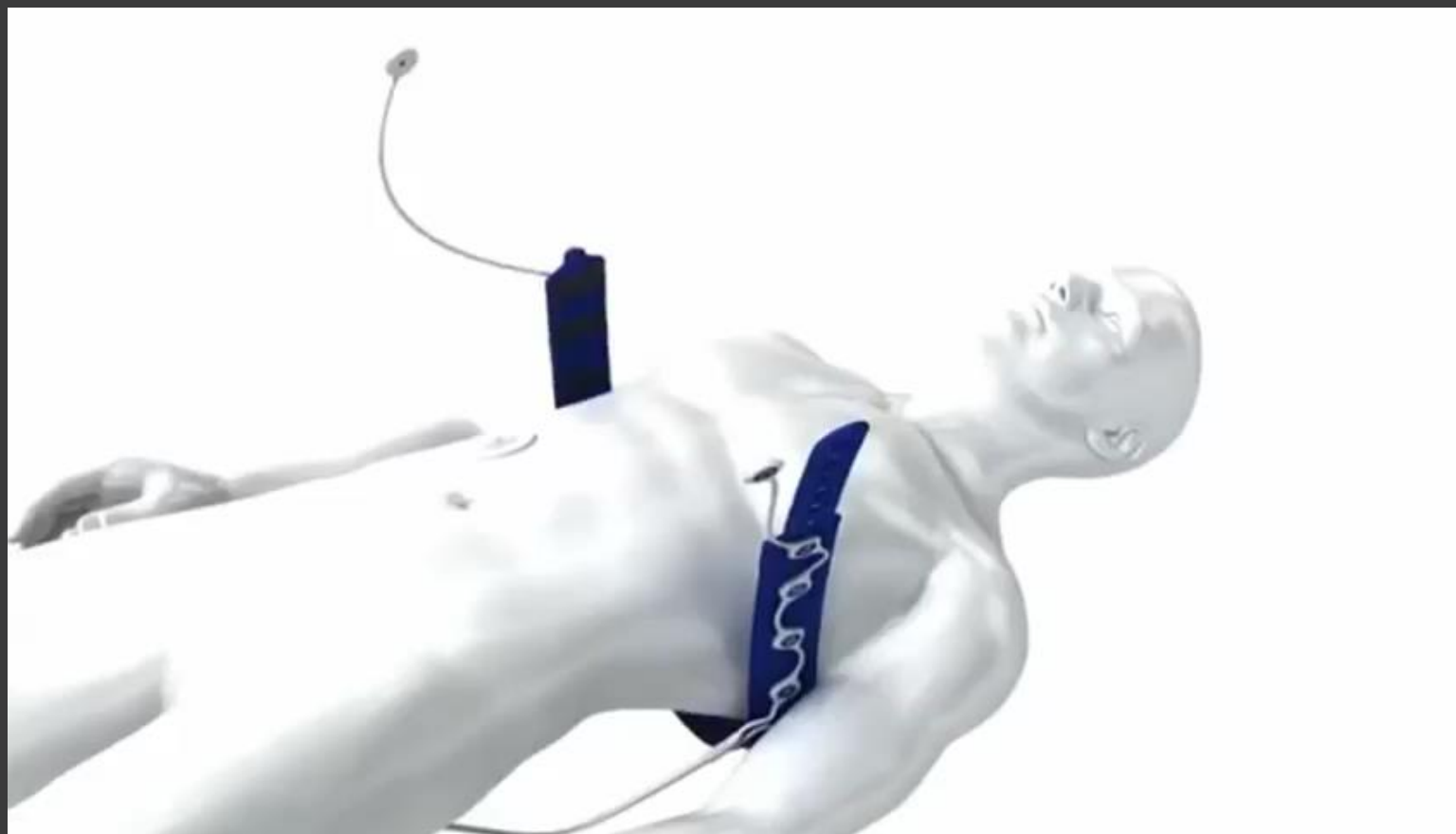


Elektrische Impedantie Tomografie

- Visualiseren van verandering in weefsel-impedantie
- 16 elektroden: een zwakke stroom op 1 elektroden paar
- Overige elektroden meten de elektrische potentialen uit dit veld

➔ Spreiding van de elektrische impedantie wordt berekend en middels algoritmen omgezet in een beeld

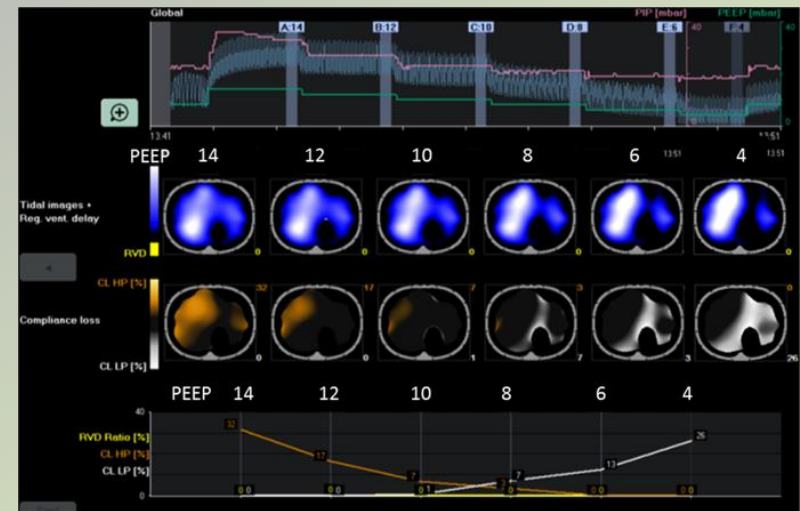
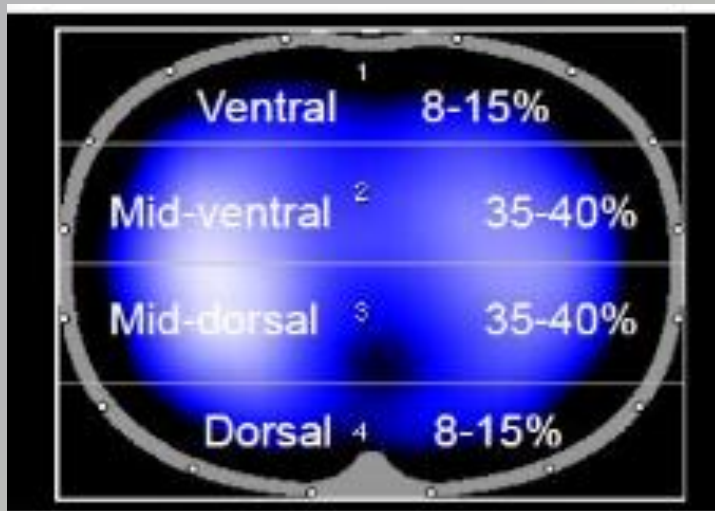




Elektrische Impedantie Tomografie

50 beelden per seconde waarop:

- de distributie van ventilatie
- de mate van cyclische alveolaire collaps/ derecruitment
- overdistensie
- shearstress



Literatuur

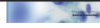


State of the art review

Chest electrical impedance tomography examination, data analysis, terminology, clinical use and recommendations: consensus statement of the TRanslational EIT developmeNt stuDy group



Inéz Frerichs¹, Marcelo B P Amato², Anton H van Kaam³, David G Tingay⁴, Zhanqi Zhao⁵, Bartłomiej Grychtol⁶, Marc Bodenstein⁷, Hervé Gagnon⁸, Stephan H Böhm⁹, Eckhard Teschner¹⁰, Ola Stenqvist¹¹, Tommaso Mauri¹², Vinicius Torsani², Luigi Camporota¹³, Andreas Schibler¹⁴, Gerhard K Wolf¹⁵, Diederik Gommers¹⁶, Steffen Leonhardt¹⁷, Andy Adler⁸, TREND study group

ELSEVIER journal homepage: www.elsevier.com/locate/rmcr 

Electrical impedance tomography and trans-pulmonary pressure measurements in a patient with extreme respiratory drive 

Atsuko Shono, Peter Somhorst*, Diederik Gommers

Department of Adult Intensive Care Medicine, Erasmus MC – University Medical Center, 's Gravedijkwal 230, 3015 CE Rotterdam, The Netherlands

ORIGINAL RESEARCH 

Clinical implementation of electric impedance tomography in the treatment of ARDS: a single centre experience

Serge J. H. Heines¹  · Ulrich Strauch¹ · Marcel C. G. van de Poll^{1,2,3} · Paul M. H. J. Roekaerts^{1,4} · Dennis C. J. J. Bergmans¹

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E.I.T. om behandeling te sturen
met als doel VILI te voorkomen bij
extreme ademdrive

E.I.T. bij ARDS



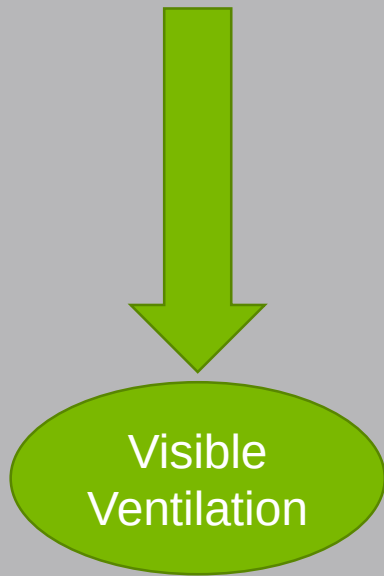
Doelstelling, vraagstelling en setting

Middels data gegenereerd door Elektrische Impedantie Tomografie, werd de mate van derecruitment gedurende twee verschillende methodes van Spontaneous Breathing Trial met elkaar vergeleken.

Vraagstelling:

- In welke mate is er derecruitment zichtbaar middels Elektrische Impedantie Tomografie bij een SBT middels 2 PS en Optiflow™?
- Subvraag: is er een verschil in recruitment van de longen zichtbaar tussen de groepen na SBT?

Onderzoeksopzet



Inclusie criterium:

- Alle geïntubeerde patiënten, langer dan 3 dagen beademd, welke voor tenminste de tweede keer een Spontaneous Breathing Trial middels 2 PS of Optiflow™ ondergaan en welke dit weanen minstens een half uur kunnen volhouden

NB: alle patiënten dienden te voldoen aan de SBT-safety-screening

Onderzoeksofzet

Visible
Ventilation

Exclusiecriteria:

- Thoraxtrauma
- Pacemaker en/ of ICD
- Patiënten <18 jaar
- Zwangerschap
- Patiënten die niet rechtop kunnen zitten (30 graden)
- Patiënten bij wie de E.I.T.-band niet geplaatst kan worden en/ of met een BMI>50
- Tidal-volume <200ml
- Patiënten met unilaterale pulmonale afwijkingen, duidelijk zichtbaar op X-thorax (longcontusie, atelectase, infiltraat, pleuravocht etc.)

MST

Methodiek

- Tussen 1 januari en 30 april 2019
- Op T0 (15 minuten voor de SBT), T1 (de eerste 15 minuten van de SBT) en T2 (de eerste 15 minuten na de SBT) werden:
 1. **E.I.T.-metingen** vastgelegd teneinde alveolaire collaps en overdistensie te detecteren
 2. **vitale functies** geregistreerd teneinde een falende weanpoging te detecteren
 3. **meetgegevens van de beademingsmachine** geregistreerd om veranderingen in impedantie-beelden te kwantificeren
- Beelden en meetwaarden werden geanonimiseerd opgeslagen, geanalyseerd en verwerkt

Resultaten

Deze studie is gebaseerd op de methode zoals toegepast door Bickenbach

Data van 9 patiënten bruikbaar: 5 SBT middels 2 PS, 4 SBT middels Optiflow™

Karakteristieken (N=9)

<i>Leeftijd gemiddeld</i>	<i>71 jaar</i>
<i>Geslacht man</i>	<i>33,3 (%)</i>
<i>Geslacht vrouw</i>	<i>66,6 (%)</i>
<i>Gemiddeld aantal beademingsdagen</i>	<i>16</i>
<i>Beademingsindicatie</i>	
<i>Primair pulmonaal</i>	<i>33,3%</i>
<i>Secundair pulmonaal</i>	<i>66,6%</i>

Basiskarakteristieken.

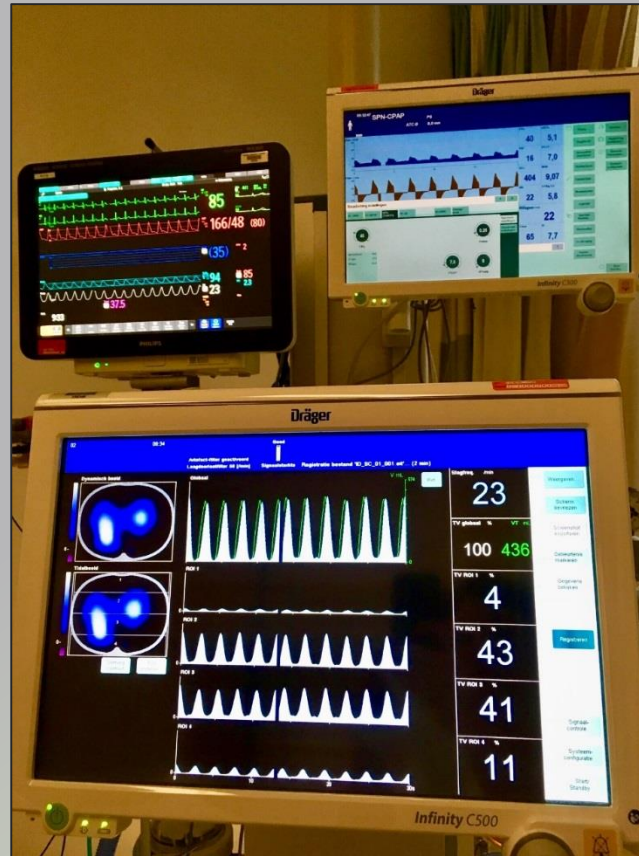
Analyse van meetwaarden en observaties

deel 1: analyse E.I.T.-beelden



E.I.T. beelden toonden bij geen van de patiënten alveolaire collaps of overdistensie

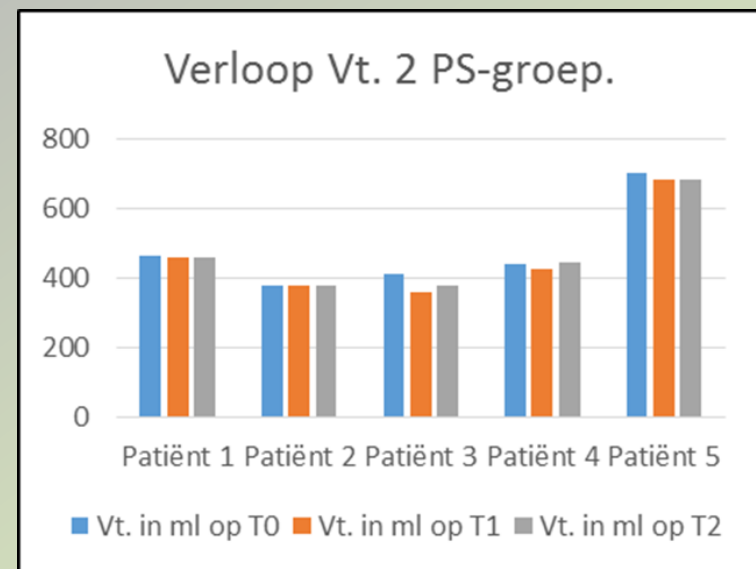
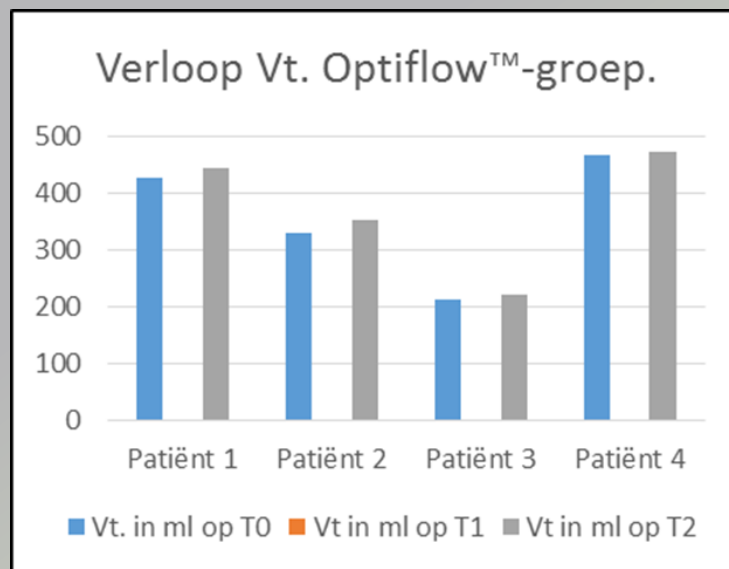
Analyse van meetwaarden en observaties deel 2 : vitale functies



Er was bij geen van de patiënten sprake van een falende weanpoging

Analyse van meetwaarden en observaties deel 3: gegevens beademingsmachine

- Mann Whitney U Test: statistisch significant verschil in teugvolumina tussen Optiflow™- en 2 PS-groep op T0 en T2
- Teugvolume in Optiflow™ groep neemt toe van T0 naar T2
- Teugvolume in 2 PS groep neemt (bij 4 van de 5 patiënten) af van T0 naar T2



Resultaten

- Een vergelijking tussen de 2 PS groep en de Optiflow™-groep is mogelijk in de fase T0 en T2. Deze vergelijking laat een statistisch significant verschil zien ($P=0.014$).
- De Optiflow™-groep heeft na de SBT in zijn geheel een groter teugvolume dan in T0. E.I.T. beelden tonen geen overdistensie.
- De 2 PS groep laat daarentegen een afname aan teugvolumina zien van T0 naar T2. E.I.T. beelden laten geen alveolaire collaps/derecruitment zien.

Conclusie en aanbevelingen

Ontwennen middels Optiflow™ laat geen derecruitment zien, er is sprake van een toename aan teugvolume na SBT ten opzichte van voor de SBT.

Verder onderzoek, in gerandomiseerde setting, om een verschil in (de)recruitment tussen de verschillende weanmethodieken aan te tonen, is nodig.

Rol Ventilation Practitioner op micro-nivo

- Doel: het continu borgen van de kwaliteit van zorg op het gebied van respiratie en ventilatie zowel binnen als buiten het ICC zowel door het up-to-date houden van kennis en kunde als het delen ervan.
- Mijn specifieke missie:
 - Het uitbreiden van de toepassing van Elektrische Impedantie Tomografie

Decremental
PEEP-trials

Voorkomen
PSILI/ VILI

Patiëntgericht
weanen

Rol Ventilation Practitioner op meso- en macronivo

Binnen het MST ben ik een van de deskundigen op het gebied van respiratie, tracheacanules, zuurstoftherapie en beademen. Ik ben ook nog Oncologie verpleegkundige. Mijn tweede specifieke missie:

- Het optimaliseren van de zorg rondom respiratie en ventilatie van de Hemato Oncologische-patiënt

Buiten het MST:

- Actieve rol binnen het netwerk van Practitioners







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SBT-safetyscreening

SBT safetyscreening: als alle 9 ontwencriteria met "ja" zijn beantwoordt, kan men starten met een SBT.

- | | |
|---|---|
| 1 | Zijn de teugvolumes $>6\text{ml/kg PBW}$? |
| 2 | Is de ademhalingsfrequentie $<35/\text{min}$? |
| 3 | Is de $\text{PaO}_2/\text{FiO}_2$ ratio $\geq 27\text{ kPa}$, S/F ratio ≥ 206 ? |
| 4 | Is de $\text{PEEP} \leq 8\text{cmH}_2\text{O}$ en $\text{PS} < 8$? (in overleg met arts is een hogere PEEP en PS toegestaan bv. bij auto- PEEP/ COPD). |
| 5 | Is de hoestreflex intact? (Hoestreflex bij tracheaal zuigen en/of spont. hoesten) |
| 6 | RASS score ≥ -3 en $< +2$? |
| 7 | Is de temperatuur $<38,5\text{ C}$? |
| 8 | Meting P0.1 tussen -2 en -4 ? |
| 9 | Meting $\text{NIF} \geq -35$? |

	Vitalie functies	T0	T1	T2	EIT	T0	T1	T2	
Patiënt 1.	Hardfrequentie	88	88	88	ROI 1	3	3	2	
	RR/ ABP	181/54	178/54	168/51	ROI 2	39	42	45	
	Saturatie	95	94	94	ROI 3	45	40	40	
	Temperatuur	37.4	37.5	37.5	ROI 4	13	15	13	
	AH frequentie	22	24	21	Optm.: geen tekenen van derecruitment aan 2 PS.				
SBT 2 PS	Tidal Volume	465	461	458	Vt. met 2% afgenomen na SBT.				
	RSB-Index	47	52	46					
	Hardfrequentie	76	77	76	ROI 1	6	5	3	
	RR/ ABP	150/56	160/59	144/51	ROI 2	22	22	22	
	Saturatie	96	97	97	ROI 3	42	41	42	
Patiënt 2	Temperatuur	36.3	36.3	36.2	ROI 4	30	32	33	
	AH frequentie	20	21	16	Optm.: geen tekenen van derecruitment aan 2 PS.				
	Tidal Volume	380	377	376	Vt. met 1,1% afgenomen na SBT.				
	RSB-Index	53	56	43					
	Hardfrequentie	96	97	101	ROI 1	5	7	5	
SBT Optiflow™.	RR/ ABP	133/50	124/47	113/46	ROI 2	34	33	34	
	Saturatie	100	100	100	ROI 3	50	52	51	
	Temperatuur	37.1	37.1	37.0	ROI 4	11	8	10	
	AH frequentie	20	24	19	Optm.: geen tekenen van derecruitment aan Optiflow™.				
	Tidal Volume	426	-	444	Vt. met 4,2% toegenomen na SBT.				
Patiënt 3.	RSB-Index	47	-	43					
	Hardfrequentie	116	110	101	ROI 1	8	6	7	
	RR/ ABP	120/65	103/77	102/65	ROI 2	46	41	40	
	Saturatie	97	99	99	ROI 3	34	35	38	
	Temperatuur	37.5	37.5	37.5	ROI 4	12	18	15	
SBT 2 PS	AH frequentie	20	28	30	Optm.: geen tekenen van derecruitment aan 2 PS, wel een afname aan Vt van 8%, hetgeen niet direct herstelde toen patiënt weer aan CPAP lag na SBT. Ook RSB-Index neemt toe.				
	Tidal Volume	413	360	380					
	RSB-Index	48	78	79					
	Hardfrequentie	77	86	86	ROI 1	9	14	12	
	RR/ ABP	112/47	129/59	140/68	ROI 2	24	29	28	
SBT Optiflow™.	Saturatie	100	100	100	ROI 3	53	44	46	
	Temperatuur	37.2	37.2	37.4	ROI 4	14	13	15	
	AH frequentie	22	27	21	Optm.: geen tekenen van derecruitment aan Optiflow™.				
	Tidal Volume	328	-	353	Vt. na SBT toegenomen met 7,6%				
	RSB-Index	67	-	59					
Patiënt 4.	Hardfrequentie	73	79	89	ROI 1	12	11	12	
	RR/ ABP	110/40	115/38	120/40	ROI 2	49	50	50	
	Saturatie	94	98	100	ROI 3	22	23	24	
	Temperatuur	37.2	37.2	37.2	ROI 4	17	16	14	
	AH frequentie	20	17	19	Geen tekenen van derecruitment aan 2 PS. Vt. minimaal toegenomen met 0,45% na SBT. Zeer veel wit sputum.				
SBT 2 PS	Tidal Volume	440	423	442					
	RSB-Index	45	40	43					
	Hardfrequentie	87	85	82	ROI 1	6	6	7	
	RR/ ABP	156/70	171/76	149/66	ROI 2	68	67	70	
	Saturatie	97	94	94	ROI 3	21	21	17	
SBT Optiflow™.	Temperatuur	36.2	36.4	36.4	ROI 4	5	6	6	
	AH frequentie	26	23	22	Optm.:geen tekenen van derecruitment.				
	Tidal Volume	212	-	221	Vt. toegenomen na SBT met 4,3%.				
	RSB-Index	123	-	104					
	Hardfrequentie	80	82	82	ROI 1	10	9	8	
Patiënt 5.	RR/ ABP	148/57	143/56	140/53	ROI 2	37	33	35	
	Saturatie	100	100	100	ROI 3	36	38	35	
	Temperatuur	36.0	36.0	36.1	ROI 4	17	20	22	
	AH frequentie	12	12	12	Optm.: geen tekenen van derecruitment.				
	Tidal Volume	703	682	682	Vt. na SBT afgenomen met 3%.				
SBT 2 PS	RSB-Index	17	18	18					
	Hardfrequentie	97	98	99	ROI 1	10	10	10	
	RR/ ABP	159/52	160/51	166/54	ROI 2	33	37	23	
	Saturatie	98	98	99	ROI 3	45	39	51	
	Temperatuur	36.6	36.3	36.4	ROI 4	12	14	16	
SBT Optiflow™.	AH frequentie	24	25	25	Optm.: geen tekenen van derecruitment aan Optiflow™.				
	Tidal Volume	466	-	473	Vt. na SBT toegenomen met 1,5%.				
	RSB-Index	52	-	53					