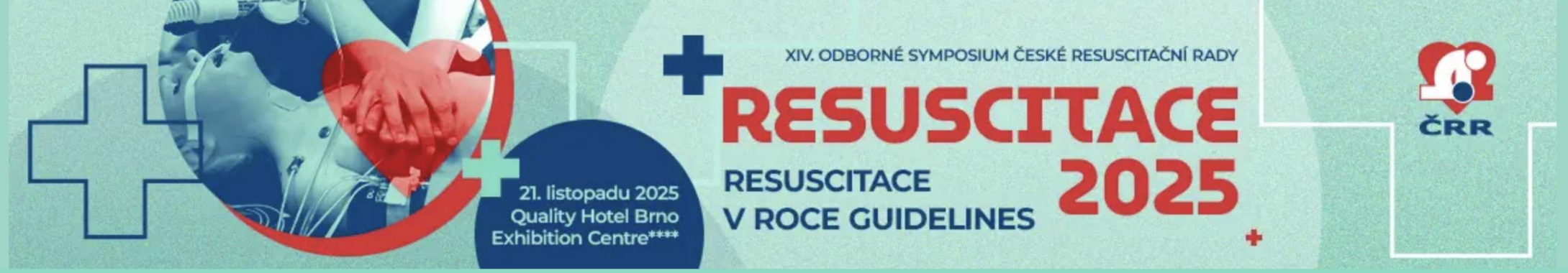


Cardiac Arrest Guidelines 2025: Is Ventilation Still Overlooked?

Pr. Abdo Khoury MD, PhD. Hon FEUSEM

Past President, The European Society for Emergency Medicine (EUSEM)

Department of Emergency Medicine & Critical Care

University Marie et Louis Pasteur, Besançon University Hospital, France

akhoury@chu-besancon.fr


Greenland
(DENMARK)
Jan Mayen
(NORWAY)
Greenland
Sea
Norwegian
Sea
Barents
Sea
Hammerfest
Murmansk
Kiruna
White
Sea
Arkhangel'sk
ICELAND
Arctic Circle


UNITED KINGDOM
NETH.
FLANDERS
BELGIUM
Lille
Amiens
GERMANY

Competing Interests

European Commission Grant for Research on Ventilation

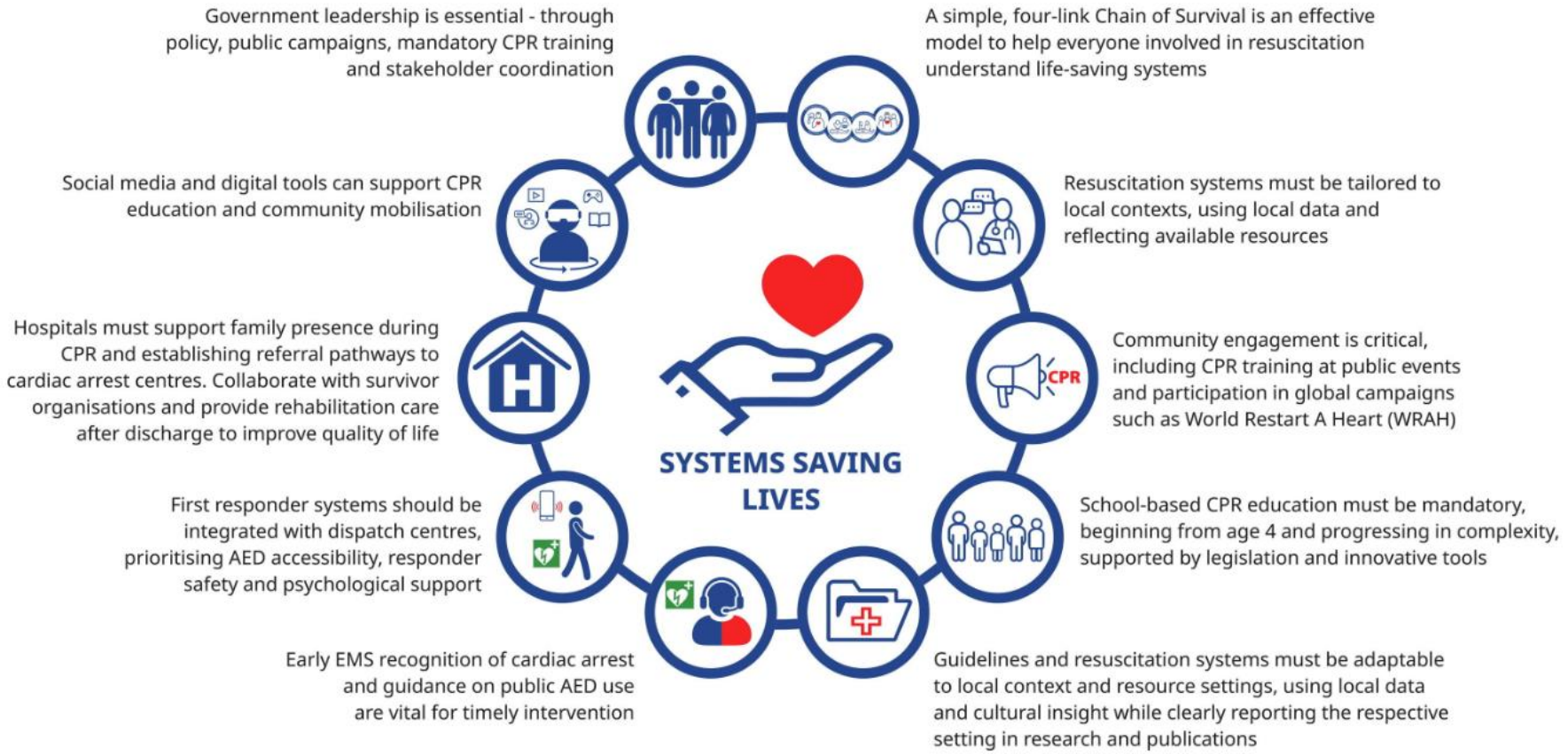
- Fisher Paykel
- Vygon
- Zoll
- Teleflex
- Sanofi
- AstraZeneca
- Baxter
- Ethypharm

3 patents for Medical Devices

ARC EON MEDICAL

Medical Advisor and Board member

Systems Save Lives



- Early warning scores
- Rapid response systems
- Medical emergency teams (MET)

- ECLS Out-of-Hospital Teams
- Hypothermia
- Etc…

Where are we today ?

Yan et al. Critical Care (2020) 24:61
https://doi.org/10.1186/s13054-020-2773-2

Critical Care

RESEARCH Open Access

The global survival rate among adult out-of-hospital cardiac arrest patients who received cardiopulmonary resuscitation: a systematic review and meta-analysis

Shijiao Yan[1,2†], Yong Gan[3†], Nan Jiang[3], Rixing Wang[4], Yunqiang Chen[5,2], Zhiqian Luo[5,2], Qiao Zong[6], Song Chen[7] and Chuanzhu Lv[4,5,2*]

- ROSC: 29,7%
- Survival rate to admission:22,0%
- Survival rate to discharge: 8,8%
- 1-month survival:10,7%
- 1-year survival:7,7%

Systematic review and meta- analysis

Over 40 years of research to estimate

- The incidence of ROSC
- Rate of survival to admission
- Rate of survival to discharge
- 1-month survival rate
- 1-year survival rate among OHCA patients who received CPR.

Yan et al. Critical Care (2020) 24:61

ESC European Society of Cardiology
European Heart Journal (2022) **43**, 4817–4829
https://doi.org/10.1093/eurheartj/ehac414

CLINICAL RESEARCH
Epidemiology and prevention

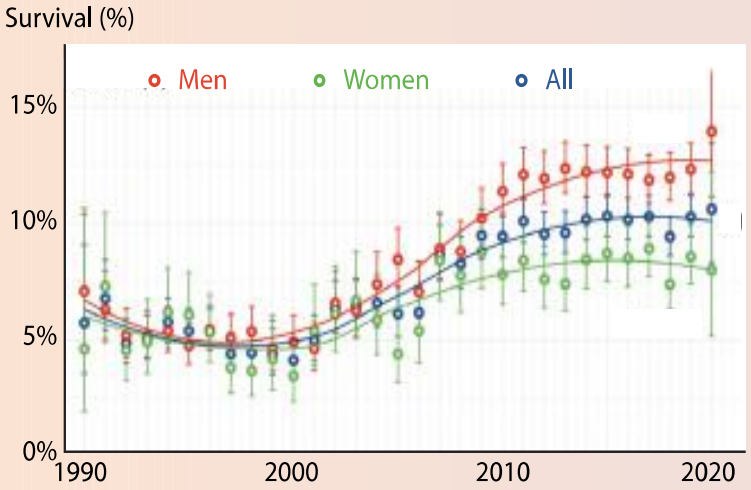
Trends in survival after cardiac arrest: a Swedish nationwide study over 30 years

European Heart Journal (2022) 43, 4817–4829

OHCA | 1990-2020 | 106,296

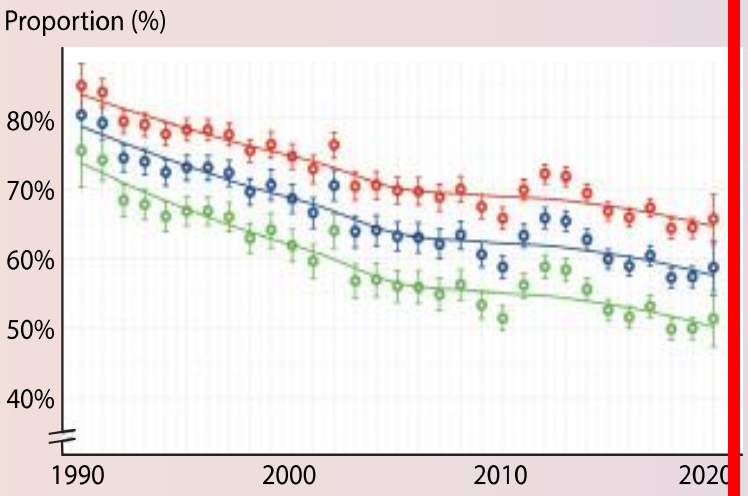
117% Overall 30-day survival

Probability increased 117% overall, 136% in men and 67% in women



55% OHCA caused by heart disease

Probability of having cardiac arrest due to heart disease declined by 55%



>90% Cerebral performance category 1–2

No improvement in neurological function among survivors between 1990 and 2020

59% Initial shockable rhythm

Probability of having an initial shockable rhythm declined by 59%

2X Delay to ambulance arrival

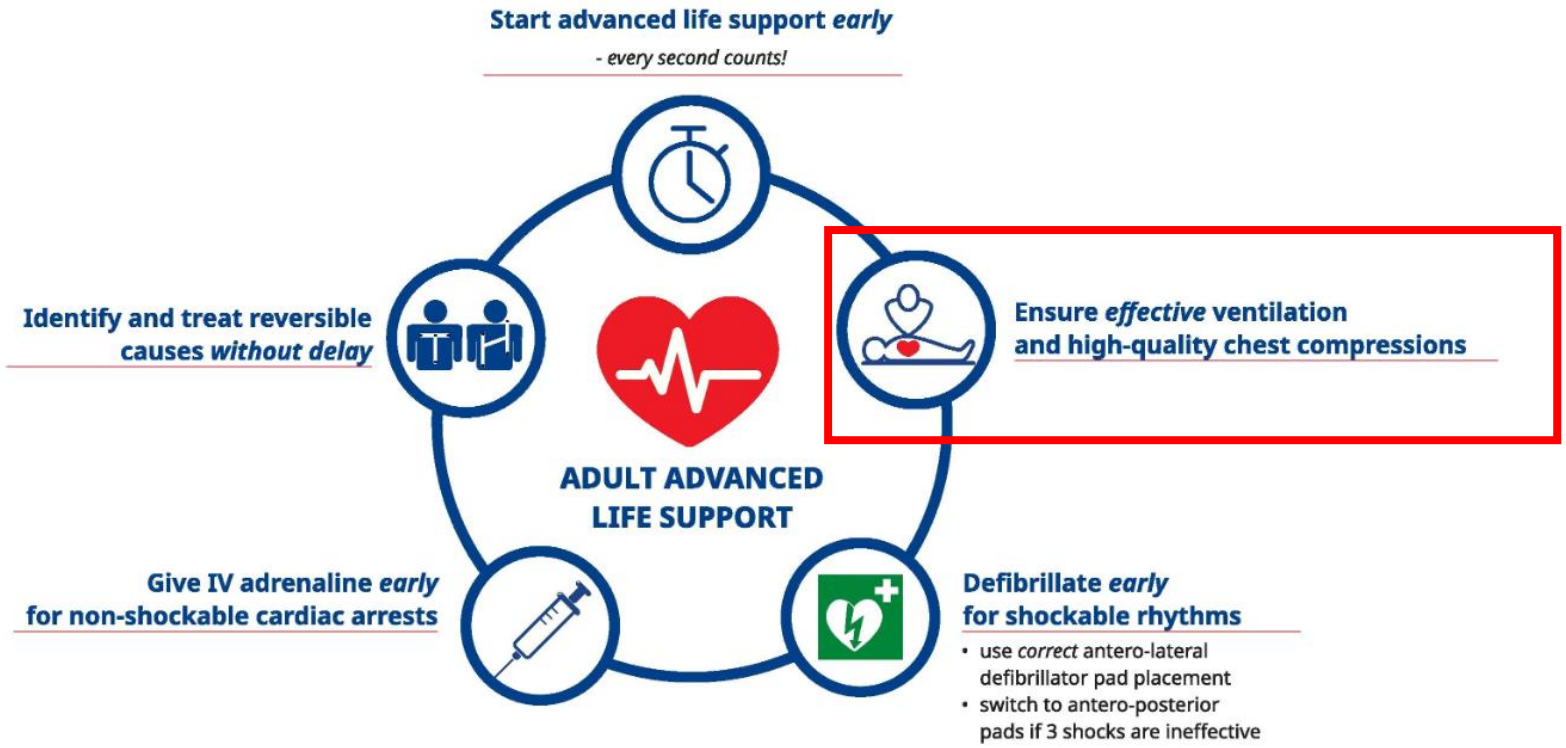
Median time from dispatch to ambulance arrival increased from 5 min to 11 min

4.8X Bystander-CPR

Probability of bystander-CPR increased 4.8-fold

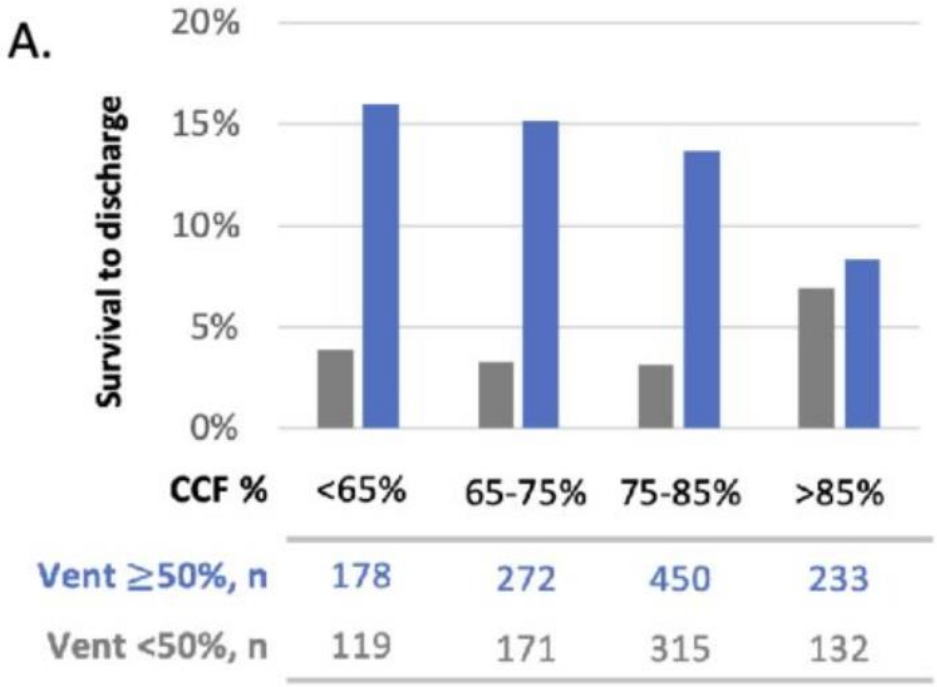
What did we miss?
What remains unfulfilled?

ALS 2025 guidelines key messages



Ensure **effective ventilation**
and high-quality chest compressions

A balance between chest compression and effective ventilation is needed



CCF %	<65%	65-75%	75-85%	>85%
Vent ≥50%, n	178	272	450	233
Vent <50%, n	119	171	315	132

The increase in the fraction of chest compressions at the expense of ventilation is harmful to survival!!

A balance between effective chest compressions and ventilation is essential.

B.YANG, Chest Compression Fraction, Bag-mask Ventilation, And Survival From Out-of-hospital Cardiac Arrest: A Multicenter Study. Presented at: AHA ReSS, Chicago, 2024

What do the ERC 2025 guidelines say ?

- Start **effective ventilation** breaths as soon as possible ensuring the **rate and tidal volume are appropriate** to prevent both inadequate ventilation (**hypoventilation**) and excessive ventilation (**hyperventilation**)
- Deliver **effective bag-mask ventilation breaths** by **optimizing mask seal** and airway patency and if necessary, use a two-person technique for bag-mask ventilation.
- Give each inspiratory breath over 1s
- **Tidal volume:** 6-8mL/kg
- **Ventilation rate:** 10 cycles/min

But is it correctly done ?

How to ventilate ?

Review Article

From Mouth-to-Mo
Evolution and Char
the Literature

Research Article

Evaluation of Ba
Manikin St

> Resuscitation. 2025 Nov 12:110895. doi: 10.1016/j.resuscitation.2025.110895. Online ah rint.

Manual Bag-Valve-Mask Ventilati
Hospital Cardiopulmon
Prospective Ob

Frédé

Ventilation Performance is weak

Abdo Kh

are. 2021 Sep-Oct;25(5):712-720.

.822481. Epub 2020 Oct 6.

ntilation in Simulated Out-of-Hospital Cardiac Arrest Resuscitation Rarely Meets Guidelines

Matthew R Neth, Justin L Benoit, Uwe Stolz, Jason McMullan

PMID: 33021857 DOI: 10.1080/10903127.2020.1822481

Perf ventilation: hov
benc ies? A review of the literatu

A. Khoury,[1] A. De Luca,[2] F. S. Sall,[3] L. Pazart[4] and G. Capellier[5]

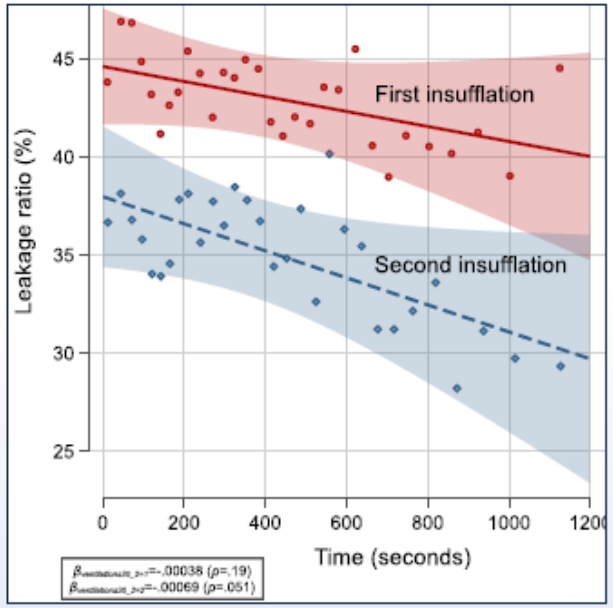
Ventilation performance is weak

RESULTS

From **May 2023 to October 2023**, we analyzed **104 consecutive patients** aged 74 years[60-86], 60% male, who received a median of 44[30-67] ventilation maneuvers.

- **Median Insufflated volume was 538 [412-645] ml**
- **Tidal volume, 291[219-405] ml**
- **Mask-leakage, 199 [119-287] ml**
- **Leakage ratio, 41% [26-54]**

Longitudinal observation during intervention-time showed a slight improvement in leakage, notably for the second insufflation of each 30:2 cycle compared to the first one.



Evolution of the Leakage ratio for the first and second insufflation manoeuvers during 20 min BLS 30-2 CPR

High levels of mask leakage (around 41% of the insufflated volume) significantly reduce the tidal volume received by the patient, resulting in **an average of only 291 mL delivered, compared to the recommended target of 500–600 mL.**

› Resuscitation. 2025 Nov 12:110895. doi: 10.1016/j.resuscitation.2025.110895. Online ahead of print.

Manual Bag-Valve-Mask Ventilation During Out-of-Hospital Cardiopulmonary Resuscitation: A Prospective Observational Study

Frédéric Lemoine [1], Daniel Jost [2], Sabine Lemoine [1], Alexandre Petermann [1], Marina Salomé [1], Bruno Tassart [1], Justin Liscia [1], Frédérique Briche [1], Olivier Bon [1], Clément Derkenne [1], Benoit Frattini [1], Stéphane Travers [1]; Paris Fire Brigade Cardiac Arrest Task Force (collaborators)

Collaborators, Affiliations + expand

PMID: 41237844 DOI: 10.1016/j.resuscitation.2025.110895

Ventilation performance is weak

(Even? Especially ? in children !)

Feasibility and Preliminary Outcomes of a Simulated Prehospital Pediatric Ventilation Scenario Using a Ventilation Feedback Device

Joseph D Finney [1] [2], Jeffrey Siegler [2], Jinli Wang [3], Elizabeth Larkin [1], Kavya John [1], Brad McClain [4], Sang Hoon Lee [4], Lauren C Riney [4], Lynn Babcock [4], Lorin R Browne [5], Fahd A Ahmad [6]

Tidal volume: participants **adhered to guidelines in only 13,5%** of the ventilations, with **significant leakages.**

Ventilation Rate: participants **adhered to guidelines in only 57%** of the ventilations.

Ventilating without a feedback is like driving without a speedometer...

There is no High-Performance CPR without High-Performance Ventilation

What is high-performance ventilation?

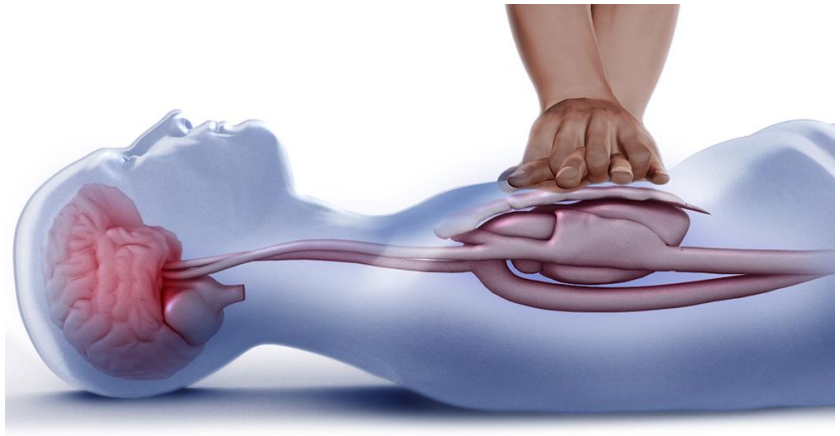
EUROPEAN RESUSCITATION COUNCIL

American Heart Association®

- **Provide an adequate volume** while minimizing the risk of gastric inflation
- **Avoid excessive gas leakage** which can result in inadequate ventilation of the patient's lungs
- **Avoid hypoventilation and hyperventilation**

Chest Rise and Adequate V_T?

- Chest lift is highly dependent on patient morphology (age, gender, height, body mass, body position and comorbidity)
- The significant change in lung compliance during chest compressions greatly reduces chest heave and makes it almost unnoticeable for an effective tidal volume.



Even when told to look at the chest rise,
rescuers continue to deliver excessive tidal volumes.

chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.itrauma.org/wp-content/uploads/2018/11/2-Comparing-Tidal-Volumes-Delivered-by-Adult-and-Pediatric-BVMs-When-EMS-Use-Chest-Rise-as-an-End-Point-for-Ventilation-Erin-Kane.pdf

Excessive leakages decrease survival

Poor ventilation

Decreases the chance of ROSC from 19.8% to 8.7%

Reduces the chance of survival from 10.3% to 4%.

Leakage can represent on average **69% of the insufflated volume** with the one-hand technique

Chang MP, Resuscitation. 2019 Aug;141:174-181

D. Otten Ann Emerg Med. 2014 Jan; 63(1): 6–12.e3.

Real Time Feedback is needed to achieve

High Performance Ventilation

Introducing **Ventilation Feedback Devices**

Ventilation Feedback Device (VFD):

Ventilation Feedback Devices (VFDs) are medical tools designed to monitor and provide real-time feedback on the quality of manual ventilation, helping rescuers deliver the correct volume, rate, and timing of breaths during CPR or respiratory support

Real-time ventilation feedback devices for out-of-hospital cardiac arrest: a review of the literature

Cameron Barcroft [1], Andrew Crow [2], Caitlin Wilson [3]

"The findings suggest **VFDs improve guideline compliance, potentially enhancing patient outcomes**.

In simulation settings, the use of VFDs **increased the accuracy and precision of delivered ventilations, reducing instance of both hyperventilation and hypoventilation**."

***British Paramedic Journal*, Volume 10, Number 2, 1 September 2025, pp. 24-33(10)**

The impact of real-time feedback on ventilation quality during out-of-hospital cardiac arrest: A before-and-after study

Ian R Drennan [1], Meji Lee [2], Jean-Philippe Héroux [3], Andrew Lee [4], John Riches [5], Jonathan Peppler [6], Annabel Poitras [7], Sheldon Cheskes [8]

"The use of real-time feedback had a **significant improvement in compliance with pre-defined ventilation targets for rate, volume, and overall quality of ventilations**."

	Overall *n* = 412	Pre-phase *n* = 195	Post-phase *n* = 228	*P* value
Avg rate, breaths/min, median (IQR)	13 (10, 17)	14 (11, 19)	12 (10, 17)	0.035
Avg volume, mL, median (IQR)	395 (326, 466)	374 (274, 453)	401 (353, 472)	0.058
Avg prop rate in target, % (SD)	41 (33)	29 (19)	53 (38)	<0.001
Avg prop volume in target, % (SD)	25 (17)	21 (16)	28 (17)	<0.001
Avg prop overall in target, % (SD)	13 (15)	7 (10)	19 (17)	<0.001

Abstract Or125: Ventilation Monitoring in Out-of-Hospital Emergency Care

Tom Aufderheide, MD,MS, Jacob Labinski, BA, Riccardo Colella, DO, MPH, Benjamin Weston, MD, Jamie Jasti, MD, MS, Aniko Szabo, PhD, Farheen Chunara, MS, Thomas w Engel, II, MD, Matthew Chinn, MD, Timothy Lenz, MD, Jason Liu, MD, Keith Mausner, MD, Christopher Monti, PhD, Rajat Kalra, MBChB, MS, Jason Bartos, MD, PhD, Demetris Yannopoulos, MD, and Tom Grawey, DO SHOW FEWER | AUTHOR INFO & AFFILIATIONS

Circulation • Volume 152, Number Suppl_3 • https://doi.org/10.1161/circ.152.suppl_3.Or125

American Heart Association.
Professional Heart Daily

#ReSS25

"Use of real time feedback resulted in a **statistically significant and clinically meaningful improvement in delivery of ventilation guidelines** during resuscitation from out-of-hospital cardiac arrest"

Table 1: In-target Percent (%) for Ventilation and Manual Chest Compressions (Within-Person, mean ± SD)

Ventilation Endpoints	Before (N=148)	After (N=130)	P Value
Ventilations in Target for Rate (%)	47.7±25.1	74.4±24.1	<0.0001
Ventilations in Target for Volume (%)	15.3±15.4	45.4±23.8	<0.0001
Ventilations in Target for Rate and Volume (%)	7.5±9.6	39.0±23.3	<0.0001

Give indications on insufflation only

Absolutely **NO** Feedback on **Expiration** or **Tidal Volume**

Introducing **EOlife**

Real time feedback about:

- Tidal volume
- Insufflated volume
- Leakage
- Ventilation rate

EOlife made it possible to improve the delivery of an adequate tidal volume by 70% under simulated conditions.*

*Khoury A, De Luca A, Sall FS, Pazart L, Capellier G. Ventilation feedback device for manual ventilation in simulated respiratory arrest: a crossover manikin study. Scand J Trauma Resusc Emerg Med. 2019;27(1):93. Published 2019 Oct 22. doi:10.1186/s13049-019-0674-7

Ventilation feedback device for manual ventilation in simulated respiratory arrest: a crossover manikin study

Abdo Khoury[1*], Alban De Luca[2], Fatimata S. Sall[3], Lionel Pazart[4] and Gilles Capellier[1]

SCANDINAVIAN JOURNAL OF
trauma, resuscitation
& emergency medicine

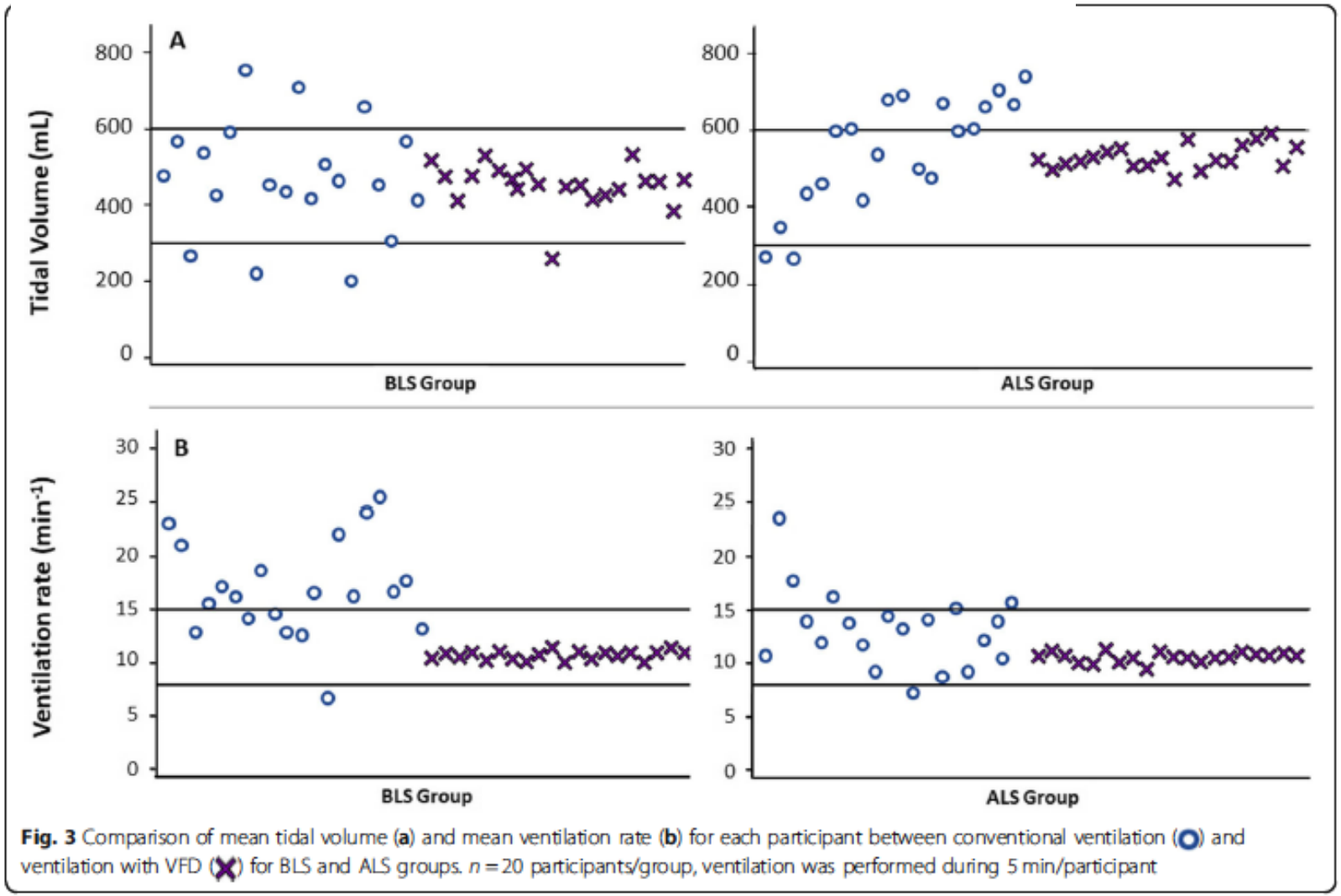


Fig. 3 Comparison of mean tidal volume (**a**) and mean ventilation rate (**b**) for each participant between conventional ventilation (○) and ventilation with VFD (×) for BLS and ALS groups. $n = 20$ participants/group, ventilation was performed during 5 min/participant

90% provided quality ventilation

Khoury et al. Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine (2019) 27:93

What do the **ERC 2025 guidelines** say ?

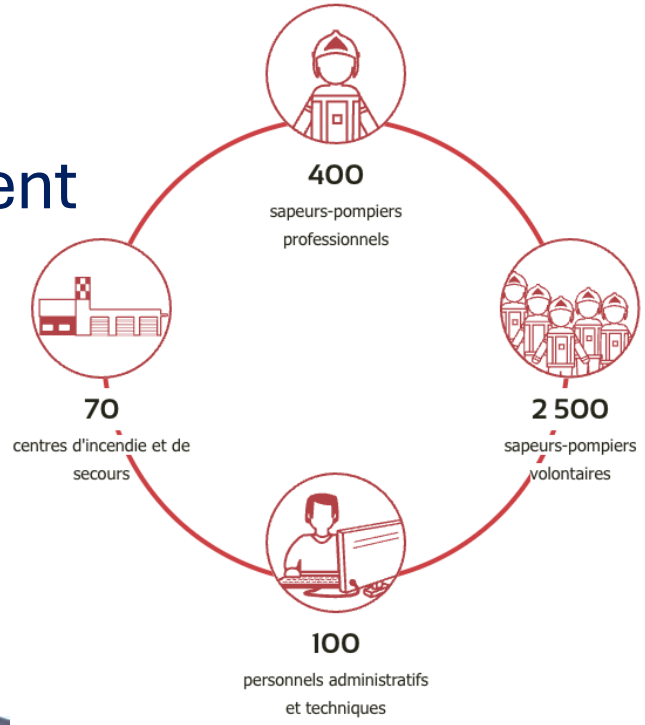
“The ERC recommends that where ventilation feedback devices are implemented, it should only occur in a highly controlled manner”

What Does “Highly Controlled Environment” Mean?

- **Proper training** of all emergency personnel using the device, with evaluation and validation of user's skills,
- Ensuring the device is **implemented consistently** and used in the same way across all teams
- Continuous **post-intervention data analysis** to monitor performance and outcomes.

EOlife deployment in SDIS 25

An example of deployment in controlled environment

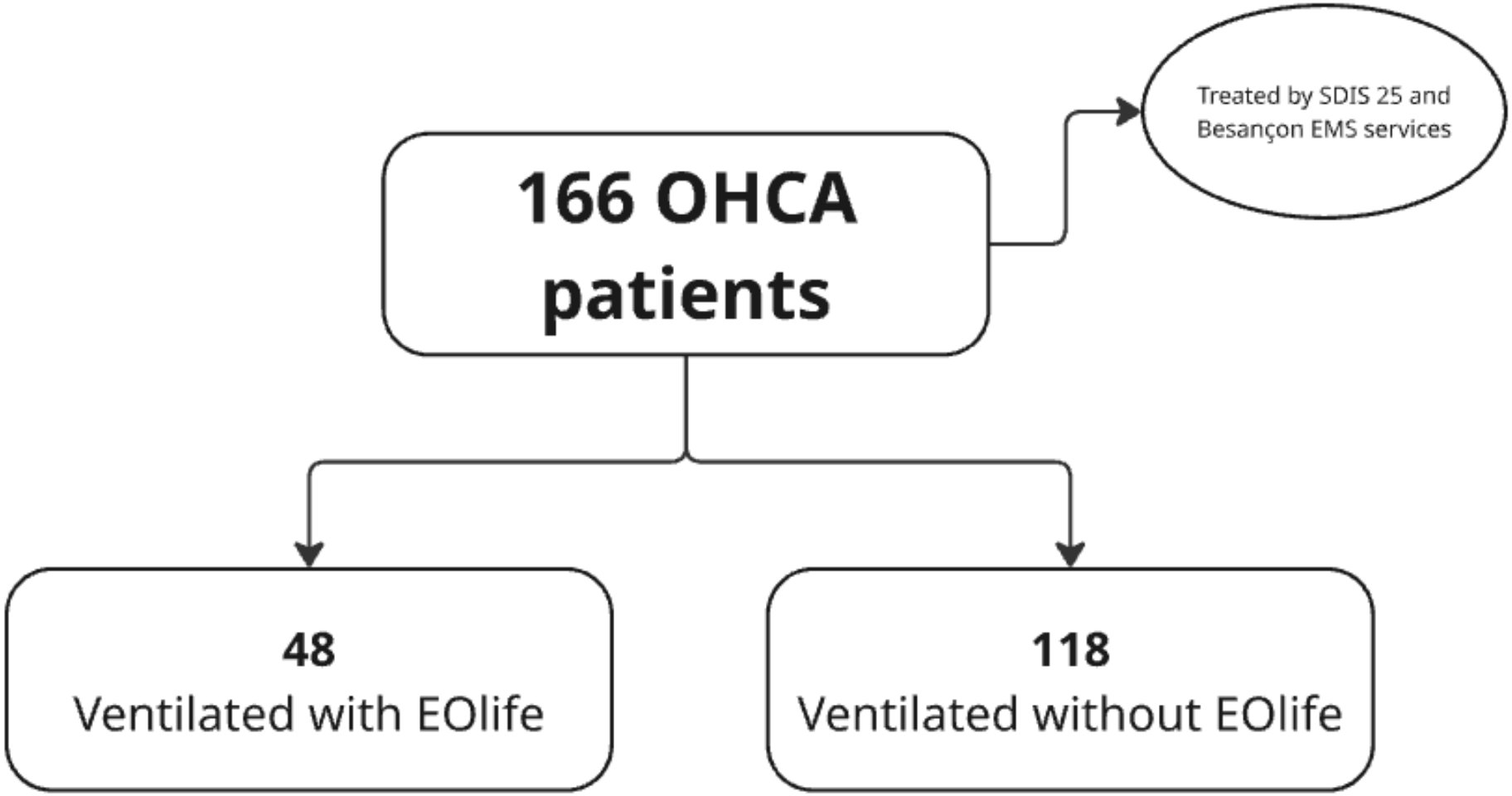


Progressive deployment since 2023:

- **75 ambulances** equipped
- **All stations** equipped with a training devices
- Integration of the device in the training protocols
- Analysis of the field feedback and data to improve care

EOlife deployment in SDIS 25

Feedback in 2024



Unpublished data

EOlife deployment in SDIS 25

Feedback in 2024

Outcomes			
Variable	**With EOlife**	**Without EOlife**	**p-value**
ROSC (%)	25.0	16.10	p = 0.1
1-Day Survival (%)	16.67	8.47	p = 0.07
30-Days Survival (%)	10.42	4.24	p = 0.077
Good neurological outcomes (CPC 1) (%)	10.42	3.39	p = 0.046
ECC number (<5, ≥5, %)	**<5**:100 / **≥5**:0.00	**<5**:66.67 / **≥5**:33.33	p = 0.018

Patient benefiting from EOlife had:

- **2-times more 30-days survival rate** (trend)
- **3-times more good neurological outcomes ! (significant, p<0,05)**

Unpublished data

Vt impact on patient outcomes

Multicenter Study > Circulation. 2023 Dec 5;148(23):1847-1856.
doi: 10.1161/CIRCULATIONAHA.123.065561. Epub 2023 Nov 12.

Bag-Valve-Mask Ventilation and Survival From Out-of-Hospital Cardiac Arrest: A Multicenter Study

Ahamed H Idris [1], Elisabete Aramendi Ecenarro [2], Brian Leroux [3], Xabier Jaureguibeitia [2], Betty Y Yang [1], Sarah Shaver [1], Mary P Chang [1], Tom Rea [4], Peter Kudenchuk [5], Jim Christenson [3 6], Christian Vaillancourt [7], Clifton Callaway [8], David Salcido [8], Jonas Carson, Jennifer Blackwood [9], Henry E Wang [10]

Affiliations + expand

PMID: 37952192 PMCID: PMC10840971 DOI: 10.1161/CIRCULATIONAHA.123.065561

1976 ACEH (adultes)

60% → **Hypoventilation**

25,2% ROSC

4,1% survival

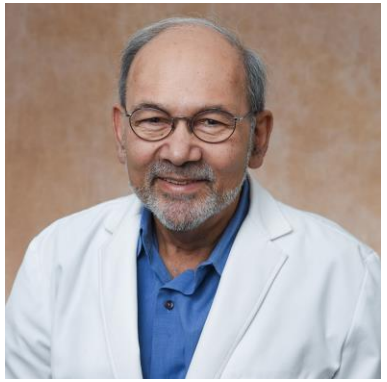
2,4% mRS 3 ou -

40% → **Ventilation « adequate »**

40,7% ROSC

13,5% survival

10,6% mRS 3 ou -



Better Vt triple survival rate.

Better Vt quadruple chances of survival with good neuro functions.

VIEWPOINT

Ventilation feedback devices in cardiopulmonary resuscitation: bridging the gap for optimal resuscitation practices

Khoury, Abdo[a,b]; Hachimi-Idrissi, Said[c,d,e]; The RACE Study Group

By enabling precise adherence to evidence-based guidelines, **VFDs** have the potential to **elevate CPR quality** and significantly **improve survival** outcomes.

The **integration of such tools** is not merely a technological advancement but a **vital strategy** for **improving** global resuscitation **outcomes** and ensuring the **highest standards** of emergency care.

Effective

Ventilation in 2025 ?

High Quality

Ventilation !

EOlife

in all circumstances