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From CPR to targeted CPR to targeted eCPR to CARL - a paradigm^shift in advanced cardiopulmonary resuscitation

Introduction International guidelines on cardiopulmonary resuscitation, CPR, contain a *universal* algorithm, suggesting a "one size fits all" approach. In contrast, patient centered, individualized resuscitation concepts form an emerging paradigm. These principles are increasingly being applied to all parts of the *chain of survival*, including advanced resuscitation measures such as extracorporeal CPR (eCPR). We developed the principle of **"Controlled Automated Repefusion of the whoLe body"** (CARL)[1], in the context of this evolution in patient centricity. Here we describe key features of a goal-directed approach to CPR, eCPR and finally, CARL therapy.

conventional CPR

BLS, ALS

- Oxygenation: 100% Oxygen in ALS [3]
- Ventilation: via $etCO_2$
- Perfusion: Restitutes low blood flow in an uncontrolled fashion
- Quality of closed chest compressions determines perfusion quality. It can be enhanced by real-time CPR-feedback devices
- Post-ROSC perfusion depends on own heart and hemodynamics
- Target values for single parameters are discussed for *post-arrest* therapy [4]
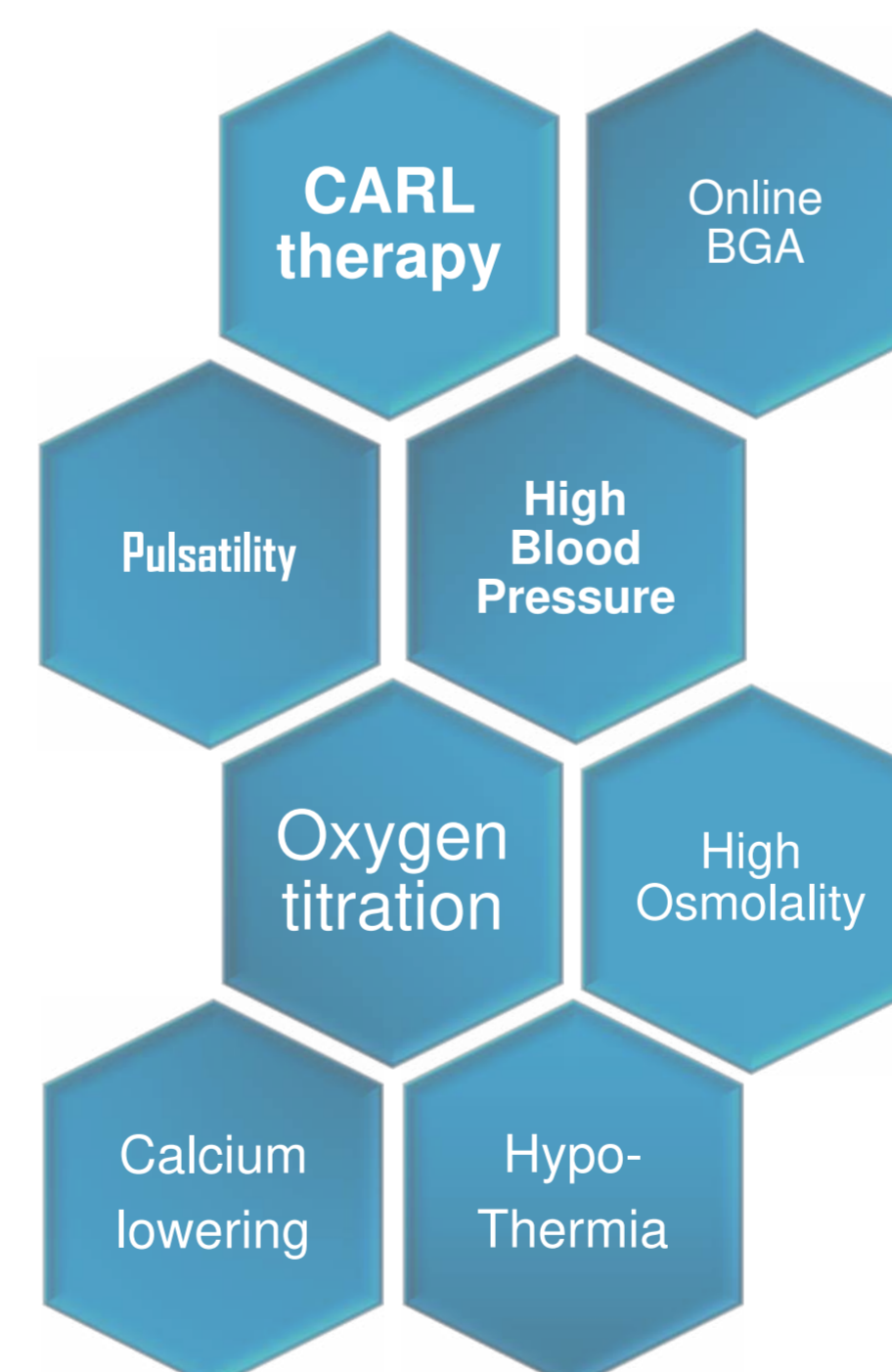
targeted CPR

diastolic blood pressure
body temperature
$etCO_2$
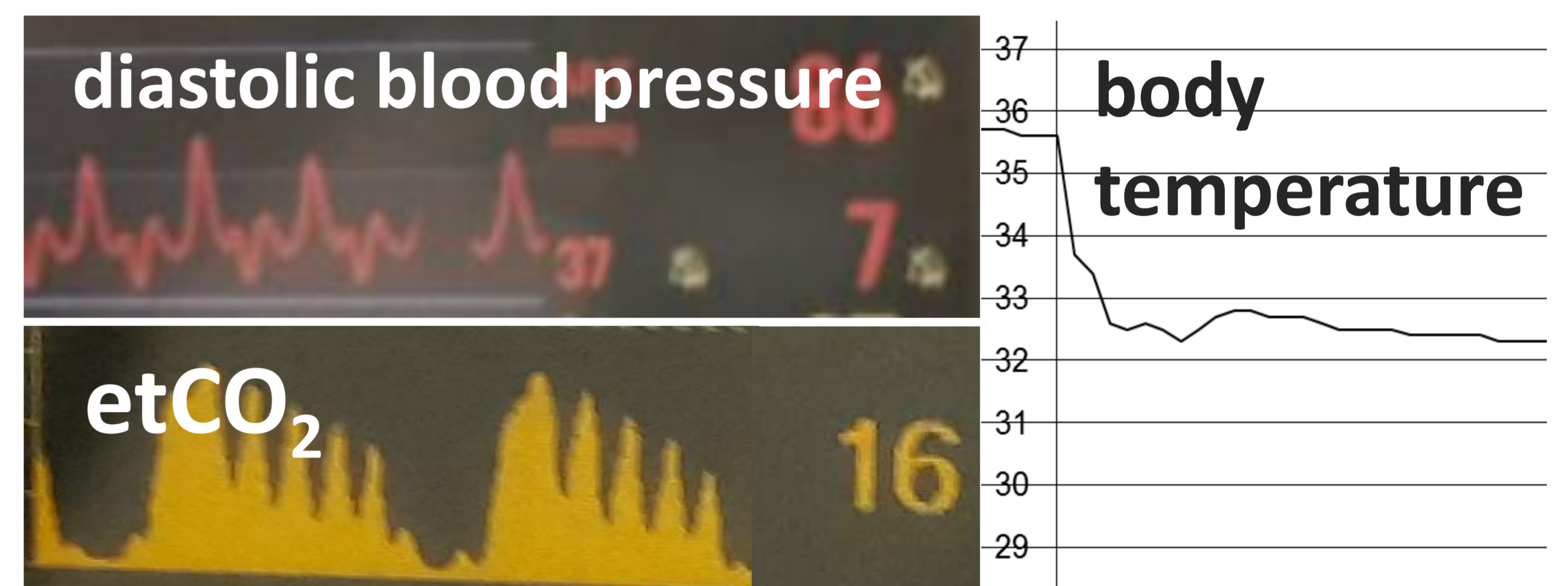
- Oxygenation: 100% Oxygen in ALS [3]
- Ventilation: via $etCO_2$
- Perfusion: Intra-arrest target values are defined to improve perfusion already *during* CPR
- A prerequisite is the capability to monitor the corresponding parameters. There are caveats like CPR-specific artifacts in arterial or capnographic waveform with an impact on target values
- Targeted temperature management is part of *post-arrest* therapy [4]

extracorporeal CPR
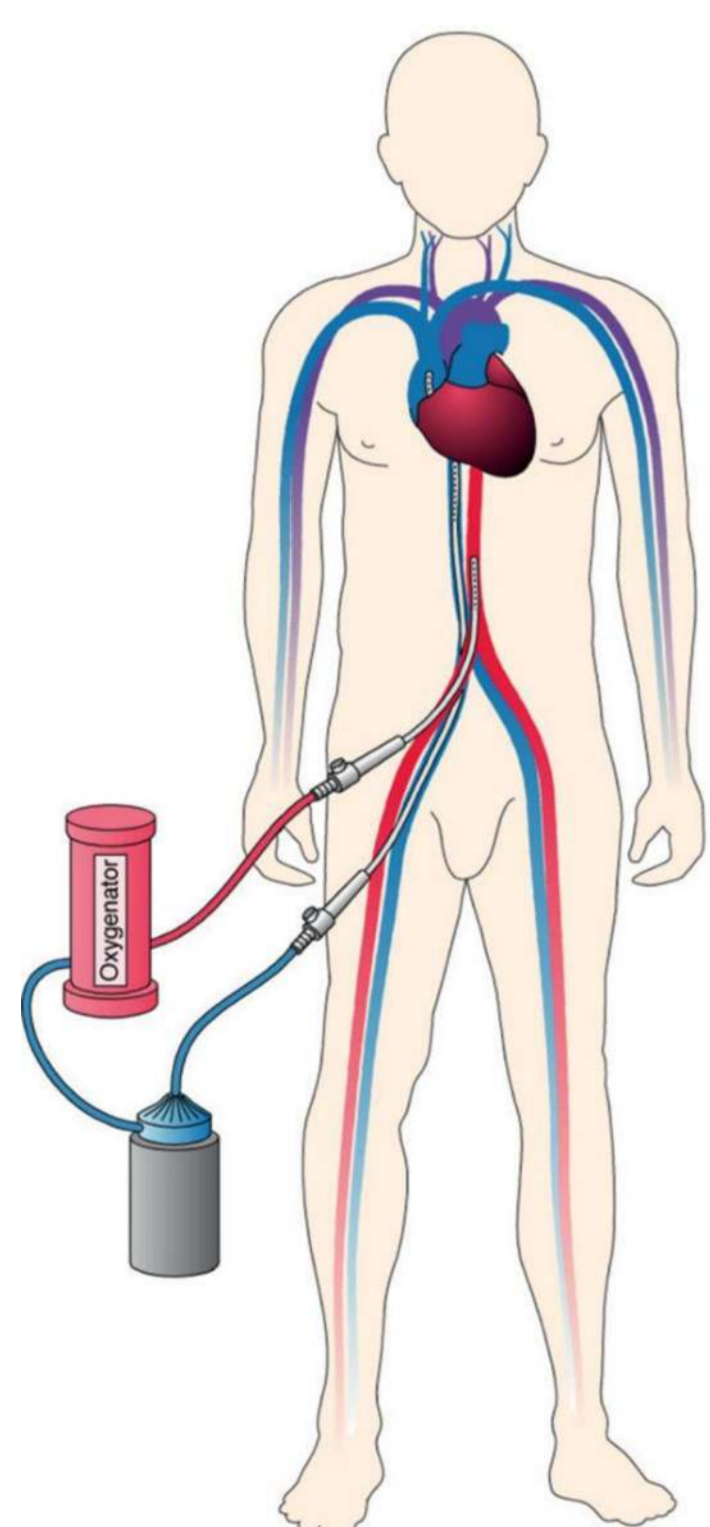
- Oxygenation: initially 100% Oxygen (in mobile use). Additional equipment required for titration.
- Ventilation: via $etCO_2$, BGA
- Perfusion: Restitutes sufficient blood flow
- Extracorporeal circuit determines perfusion quality
- Target values for single parameters are still in discussion
- Consider SOPs, best practice publications; *post- arrest* therapy guidelines

CARL therapy

CARL therapy / Online BGA / Pulsatility / High Blood Pressure / Oxygen titration / High Osmolality / Calcium lowering / Hypo-Thermia

- Treatment bundle based on extracorporeal circulation
- Aimed at limiting ischemia-reperfusion injury
- Advanced monitoring and therapy options, facilitate targeted approach
- Extracorporeal circuit determines perfusion quality
- Animal experiments: 9/10 survived 20 mins untreated arrest, 8 with good neurologic outcome [2]
- Patient series: 6/14 CPC 1 [1]

advanced

targeted

Conclusion

Advanced monitoring during CARL therapy facilitates a highly individualized, targeted therapy following refractory cardiac arrest, aimed at limiting ischemia-reperfusion injury, and combining key features from eCPR as well as goal-directed CPR.

Abbreviations
BLS, Basic Life-Support; ALS, Advanced Life-Support; ROSC; Return of Spontaneous Circulation, $etCO_2$ end-tidal carbon-dioxide, SOP; Standard Operating Procedure; BGA, Blood Gas Analysis; CPC, Cerebral Performance Category

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Handout