ECMO CPR
future form of CPR?

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TAIPEI, TAIWAN
Disclosure

✓ Travel support and speech from Siemens, Medtronic, Edward

✓ No interest of conflict for this presentation
Outline

✔ Conventional CPR
✔ ECPR in IHCA
✔ Evidence based medicine
✔ OHCA vs IHCA
✔ Hypothermia issue
✔ New innovation
Cardiac arrest - CPR

✓ The extreme ischemia-reperfusion phenomena in human
✓ The extreme disaster for individual, also for the hospital, and for the team
✓ Extracorporeal resuscitation is an emerging technique for the critical status
The Evolution of A-B-C as of 1960s
Cumulated number and proportion of ROSC as functions of the duration of resuscitation
CPR duration > 30 min, more poor outcome

Resuscitation 2007;72:394-403
Resuscitation 2003;58:297-308

Figure 3  Cumulated number and proportion of survival to discharge as functions of duration of resuscitation.
### Overall Outcomes

<table>
<thead>
<tr>
<th></th>
<th>Total Patients</th>
<th>Survived ECLS</th>
<th>Survived to DC or Transfer</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Neonatal</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Respiratory</td>
<td>28,271</td>
<td>23,791</td>
<td>20,978</td>
</tr>
<tr>
<td>Cardiac</td>
<td>6,046</td>
<td>3,750</td>
<td>2,497</td>
</tr>
<tr>
<td>ECPR</td>
<td>1,188</td>
<td>766</td>
<td>489</td>
</tr>
<tr>
<td><strong>Pediatric</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Respiratory</td>
<td>6,929</td>
<td>4,579</td>
<td>3,979</td>
</tr>
<tr>
<td>Cardiac</td>
<td>7,668</td>
<td>5,084</td>
<td>3,878</td>
</tr>
<tr>
<td>ECPR</td>
<td>2,583</td>
<td>1,432</td>
<td>1,070</td>
</tr>
<tr>
<td><strong>Adult</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Respiratory</td>
<td>7,922</td>
<td>5,209</td>
<td>4,576</td>
</tr>
<tr>
<td>Cardiac</td>
<td>6,522</td>
<td>3,661</td>
<td>2,708</td>
</tr>
<tr>
<td>ECPR</td>
<td>1,985</td>
<td>791</td>
<td>589</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>69,114</td>
<td>49,063</td>
<td>40,764</td>
</tr>
</tbody>
</table>

#### National Taiwan University Hospital (133) (NTUH)

<table>
<thead>
<tr>
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<tbody>
<tr>
<td><strong>Neonatal</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Respiratory</td>
<td>20</td>
<td>13</td>
<td>12</td>
</tr>
<tr>
<td>Cardiac</td>
<td>76</td>
<td>33</td>
<td>20</td>
</tr>
<tr>
<td>ECPR</td>
<td>23</td>
<td>12</td>
<td>11</td>
</tr>
<tr>
<td><strong>Pediatric</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Respiratory</td>
<td>68</td>
<td>31</td>
<td>25</td>
</tr>
<tr>
<td>Cardiac</td>
<td>162</td>
<td>91</td>
<td>74</td>
</tr>
<tr>
<td>ECPR</td>
<td>69</td>
<td>30</td>
<td>25</td>
</tr>
<tr>
<td><strong>Adult</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Respiratory</td>
<td>306</td>
<td>153</td>
<td>137</td>
</tr>
<tr>
<td>Cardiac</td>
<td>546</td>
<td>248</td>
<td>208</td>
</tr>
<tr>
<td>ECPR</td>
<td>450</td>
<td>166</td>
<td>148</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>1,720</td>
<td>777</td>
<td>660</td>
</tr>
</tbody>
</table>

21.2% of ELSO ECPR

2015 July NTUH
Procedure – team approach

✓ Explanation: 1 – 2 min to the family

✓ 4 teams cooperation

✓ 1 for continuous CPR (2 PHYSICIANS, COUPLE NURSES)
✓ 1 for vascular access (1–2 SURGEONS)
✓ 1 for ECMO priming (1 ECMO TECHNICIAN)
✓ 1 for family support (1 NURSE OR PHYSICIAN)

✓ Cath lab/CT preparation: R/O DISSECTION, BRAIN HEMORRHAGE

✓ OR notification: surgical intervention
Equipments

ECMO cart
ECPR case selection

WHEN TO CALL ECMO TEAM

✓ CPR 10-20 min without ROSC
  ✓ How about ROSC when you are preparing?

✓ BP maintained by bolus of epinephrine

✓ ?? Consciousness level
  ✓ Dilated pupil?
  ✓ Unresponsive to verbal?
  ✓ Unresponsive to pain?
ECPR CASE SELECTION
NTUH SINCE 1994

Inclusion criteria

- Age <= 75 yrs, extend to 80 yrs since 2001
- CPR > 10 min without returning of spontaneous circulation (ROSC)
- Blood pressure maintained by bolus of epinephrine (> 5 bolus)

Exclusion criteria

- Traumatic
- Irreversible severe brain insult
- Terminal malignancy
- Shock with elective ECLS
- Failure in weaning off CPB
- “DNAR”
ECPR procedure - VA ECMO

0 Cannulation of femoral vessels
   0 Cut-down, guide-wire based technique
0 Clear priming
0 Training young surgeons to perform the procedure for emergency

Decision following ECPR

0 Within 24 hrs
   0 Diagnosis and treatment
0 Within 72 hrs
   0 Evaluating consciousness and cardiac recovery, VAD
0 Within 5 to 7 days
   0 Arranging transplantation
   0 DNR

JACC 2003; 42:197
CCM 2008;36:2529
Lancet 2008;372:554
J Thorac Cadriovac Surg
Amazing photo

Awake with arrested heart
## Outcomes

### Table 3 Relation between weaning or survival and CPR duration

<table>
<thead>
<tr>
<th>CPR duration</th>
<th>%, (n)</th>
<th>Weanoff, %, (n)</th>
<th>Survival, %, (n)</th>
<th>OR</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 15 min</td>
<td>0% (0)</td>
<td>—</td>
<td>—</td>
<td>4.134</td>
<td>1.349 - 13.379</td>
</tr>
<tr>
<td>&lt; 30 min</td>
<td>14.1% (19)</td>
<td>63.2% (12)</td>
<td>63.2% (12)*</td>
<td>4.134</td>
<td>1.349 - 13.379</td>
</tr>
<tr>
<td>&gt; 30 min</td>
<td>85.9% (116)</td>
<td>57.8% (67)</td>
<td>29.3% (34)*</td>
<td>3.529</td>
<td>1.574 - 7.981</td>
</tr>
<tr>
<td>&lt; 45 min</td>
<td>43% (58)</td>
<td>63.8% (37)</td>
<td>50% (29)*</td>
<td>3.529</td>
<td>1.574 - 7.981</td>
</tr>
<tr>
<td>&gt; 45 min</td>
<td>57% (77)</td>
<td>54.5% (42)</td>
<td>22.1% (17)*</td>
<td>3.529</td>
<td>1.574 - 7.981</td>
</tr>
<tr>
<td>&lt; 60 min</td>
<td>65.2% (88)</td>
<td>67.0% (59)*</td>
<td>47.4% (42)*</td>
<td>9.815</td>
<td>3.124 - 40.234</td>
</tr>
<tr>
<td>&gt; 60 min</td>
<td>34.8% (47)</td>
<td>42.6% (20)*</td>
<td>8.5% (4)*</td>
<td>3.529</td>
<td>1.574 - 7.981</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100% (135)</td>
<td>58.5% (79)</td>
<td>34.1% (46)</td>
<td>9.815</td>
<td>3.124 - 40.234</td>
</tr>
</tbody>
</table>

*: p < 0.05, OR: odds ratio for survival.
Does ECMO really provide better outcome in CPR with cardiac origin?

Propensity score analysis

Yes, short term and 1 years after

Lancet 2008
ECPR in IHCA of NTUH

Additional 20% survival

ECMO can extend tolerance in CPR duration in adult

CCM 2008

Lancet 2008
Breast cancer improvement

Figure 3.1: Age standardised relative survival (%) at one, five, ten and twenty years since diagnosis, female breast cancer, England and Wales, 1971-2003

Additional 20% survival

20 years
ECPR Meta-analysis progress in result

- **1989 – 2003**: IHCA (mainly), around 50, wean rate: 20 to 66%, discharge 20 to 31%,

- **2005 – 2008**: IHCA, around 40 to 135, discharge rate: 20 – 24%, CPC 1-2: 15 – 20%

- **2009 – 2012**: mixed IHCA OHCA, around 70 – 150, discharge rate: 6 – 59%, good CPC: 20%

European Heart Journal: Acute Cardiovascular Care 2013, 2(2) 118–126
Curr Opin Crit Care 2013, 19:202 – 207
### Table 2. Extracorporeal conventional cardiopulmonary resuscitation following adult in-hospital cardiac arrest

<table>
<thead>
<tr>
<th>Source</th>
<th>Study year</th>
<th>Study region</th>
<th>Setting</th>
<th>Mean age (years)</th>
<th>CPR duration (minutes)</th>
<th>Cumulative survival to hospital discharge (survivor/total patient number) (%)</th>
<th>Favorable neurological outcome at hospital discharge (number/total patient number) (%)</th>
<th>Favorable neurological outcome in survivors (number/survivor) (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jo et al., [22] 2011</td>
<td>2004–2007</td>
<td>Korea</td>
<td>IHCA</td>
<td>58</td>
<td>37</td>
<td>34/83 (41)</td>
<td>29/83 (35)</td>
<td>29/34 (85)</td>
</tr>
<tr>
<td>Kagawa et al., [23] 2012</td>
<td>2004–2011</td>
<td>Japan</td>
<td>IHCA</td>
<td>69</td>
<td>33</td>
<td></td>
<td></td>
<td>15/18 (83)</td>
</tr>
</tbody>
</table>

CPR, conventional cardiopulmonary resuscitation; IHCA, in-hospital cardiac arrest.

### Table 3. Extracorporeal conventional cardiopulmonary resuscitation following adult out-of-hospital cardiac arrest

<table>
<thead>
<tr>
<th>Source</th>
<th>Study year</th>
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<th>Setting</th>
<th>Mean age (years)</th>
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<th>Favorable neurological outcome in survivors (number/survivor) (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ferrari et al., [18] 2011</td>
<td>2007–2008</td>
<td>Germany</td>
<td>IHCA/OHCA</td>
<td>55</td>
<td>49</td>
<td>8/22 (36)</td>
<td>8/22 (36)</td>
<td>8/8 (100)</td>
</tr>
<tr>
<td>Avalli et al., [19] 2012</td>
<td>2006–2011</td>
<td>Italy</td>
<td>IHCA</td>
<td>46</td>
<td>77</td>
<td>1/18 (5)</td>
<td></td>
<td>1/1 (100)</td>
</tr>
<tr>
<td>Kagawa et al., [23] 2012</td>
<td>2004–2011</td>
<td>Japan</td>
<td>IHCA</td>
<td>56</td>
<td>65</td>
<td></td>
<td></td>
<td>6/7 (14)</td>
</tr>
</tbody>
</table>

CPR, conventional cardiopulmonary resuscitation; IHCA, in-hospital cardiac arrest; OHCA, out-of-hospital cardiac arrest.

**Survival**
- IHCA: 30 to 40%
- OHCA: 4 to 20%

**Favorable outcome**
- IHCA: 25 to 30%
- OHCA: 4 to 14%
ECLS may have similar survival for patients with ROSC, and may not have additional survival benefit.

Not recommended ECMO for sustained ROSC.
### Consecutive ECPR cases series in recent 5 years

**Resuscitation** 2014; 1219–1224

#### Table: Duration of ischemia vs. Case count, Survival, Favorable outcome

<table>
<thead>
<tr>
<th>Duration of ischemia</th>
<th>Case count</th>
<th>Survival</th>
<th>Favorable outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OHCA N(%)</td>
<td>IHCA N(%)</td>
<td>OHCA N(%)</td>
</tr>
<tr>
<td>0</td>
<td>0(0)</td>
<td>69(34.7)</td>
<td>26(37.7)</td>
</tr>
<tr>
<td>≤ 60 min</td>
<td>8(25.8)</td>
<td>123(61.8)</td>
<td>5(62.5)</td>
</tr>
<tr>
<td>75 min</td>
<td>16(51.6)</td>
<td>165(82.9)</td>
<td>8(50.0)</td>
</tr>
<tr>
<td>90 min</td>
<td>22(71.0)</td>
<td>180(90.5)</td>
<td>12(54.4)</td>
</tr>
<tr>
<td>Total</td>
<td>31(100)</td>
<td>199(100)</td>
<td><strong>12(38.7)</strong></td>
</tr>
</tbody>
</table>
E C M O

Extreme Cardiopulmonary & Manpower Outbreak

Angel against Saten?

Or

Devil against GOD?
But, don’t forget everyone has his “blind spot”
What is the critical point in CPR?

CPR DILEMMA

“Save Heart and Lose Brain”
Concept evolution in experiment

- **CPR and ACL Alone**
  - 80% mortality with severe brain damage

- **CPR + CPB**
  - Improved survival with brain injury
  - CPR + CPB Controlled Body Reperfusate in CBP prime
    - 95% cardiac survival with minimal brain improvement (animal / human)
  - CPB + CONTROLLED REPERFUSATE IN CBP PRIME WITHOUT CPR
    - 100% heart/brain recovery in 48 hr (animal data)
Controlled Brain Reperfusion
Parameter Conclusions

PRESSURE
FLOW
TEMPERATURE
REPERFUSATE

Other Parameters require testing
(infusion duration, metabolic additives, etc...)
Reversibility vs. Irreversibility
Therapeutic Hypothermia after Out-of-Hospital Cardiac Arrest in Children


Hypothermia 155, normothermia 140

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Hypothermia Group (N=155)</th>
<th>Normothermia Group (N=140)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demographic characteristics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age — yr</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Median</td>
<td>2.1</td>
<td>1.6</td>
</tr>
<tr>
<td>Interquartile range</td>
<td>0.6–10.1</td>
<td>0.4–7.0</td>
</tr>
<tr>
<td>Age category — no. (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;2 yr</td>
<td>76 (49)</td>
<td>73 (52)</td>
</tr>
<tr>
<td>2 to &lt;12 yr</td>
<td>48 (31)</td>
<td>45 (32)</td>
</tr>
<tr>
<td>≥12 yr</td>
<td>31 (20)</td>
<td>22 (16)</td>
</tr>
</tbody>
</table>

Characteristics of the cardiac arrest

<table>
<thead>
<tr>
<th>Primary cause of the cardiac arrest — no. (%)</th>
<th>Hypothermia Group (N=155)</th>
<th>Normothermia Group (N=140)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Respiratory event</td>
<td>111 (72)</td>
<td>102 (73)</td>
</tr>
<tr>
<td>Cardiovascular event</td>
<td>14 (9)</td>
<td>18 (13)</td>
</tr>
<tr>
<td>Other</td>
<td>11 (7)</td>
<td>4 (3)</td>
</tr>
<tr>
<td>Unknown</td>
<td>19 (12)</td>
<td>16 (11)</td>
</tr>
</tbody>
</table>
Table 2. Primary and Secondary Outcomes.

<table>
<thead>
<tr>
<th>Outcome</th>
<th>1000d</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alive with VAB</td>
<td>2.76</td>
<td>0.14†</td>
</tr>
<tr>
<td>Detailed support</td>
<td></td>
<td>0.14‡</td>
</tr>
<tr>
<td>Death</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Disability</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Profound§</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moderate-t</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Good function</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alive at 1 yr</td>
<td>1.79</td>
<td>0.13†</td>
</tr>
<tr>
<td>1-yr change in V̇basin</td>
<td></td>
<td>0.13**</td>
</tr>
<tr>
<td>Death</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lowest possible V̇basin</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Decrease in V̇basin &gt;30 points</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16-30 points</td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤15 points or improved</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Targeted Temperature Management at 33°C versus 36°C after Cardiac Arrest

33°C 473, 36°C 466
From Dec 2002 to Dec 2011, 241 consecutive patients underwent E-CPR in National Taiwan University Hospital.

The test of “therapeutic hypothermia for E-CPR” protocol was introduced to our hospital in 2007.

The decision was made by attending physician.

35 patients with therapeutic hypothermia (TH) intentionally if unconsciousness

206 patients were treated by E-CPR without TH
In the non-hypothermic, the extracorporeal circuits heater-cooler were set at 37 Celsius degree at first 24 hours.

In the hypothermic group, the circuits heater-cooler were set at 34 Celsius degree for 24 hours, then rewarmed up 0.5 Celsius degree per 4 hours till 37 Celsius degree.

The core body temperature were measured by intrabladder catheter.
Scatter Diagram for Body Temperature (Total ECPR)

More nonsurvivors
Survival Probability in Non-TH group (Logistic Regression Analysis - BT)

\[ P_{\text{Survival}} = \frac{e^{18.480 + (0.502 \cdot BT)}}{1 + e^{18.480 + (0.502 \cdot BT)}} \]

Likelihood Ratio Test Statistic: 9.844 (\( p = 0.002 \))

<table>
<thead>
<tr>
<th>Ind. Variable</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>Wald Statistic</th>
<th>( p ) value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-18.480</td>
<td>3.497</td>
<td>8.060</td>
<td>0.004</td>
</tr>
<tr>
<td>BT</td>
<td>0.502</td>
<td>3.575</td>
<td>8.658</td>
<td>0.003</td>
</tr>
</tbody>
</table>

Lower BT

Lower survival
Survival Status with Non−TH group

- Non-Survival (n = 74)
- Survival (n = 58)

- Non-Survival (n = 43)
- Survival (n = 42)

- Non-Survival (n = 26)
- Survival (n = 6)

- Non-Survival (n = 5)
- Survival (n = 10)

**Slow HR, Less SD in non−TH \(\rightarrow\) better outcome**

SD: standard deviation

HR (beats/min)

2015/8/31
YS CHEN
Logistic Regression Analysis of Survival Probability

Non-Hypothermia

Heart rate

\[ P_{\text{Survival}} = \frac{e^{27.268(0.0187 \cdot HR) + (0.784 \cdot BT)}}{1 + e^{27.268(0.0187 \cdot HR) + (0.784 \cdot BT)}} \]

Likelihood Ratio Test Statistic: 14.988 (\( p = 0.001 \))

<table>
<thead>
<tr>
<th>Ind. Variable</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>( 5% )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-27.268</td>
<td>8.95</td>
<td></td>
</tr>
<tr>
<td>HR</td>
<td>-0.0187</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>BT</td>
<td>0.784</td>
<td>0.24</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Ind. Variable</th>
<th>Odds Ratio</th>
<th>( 5% )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>1.438E-012</td>
<td>3.40</td>
</tr>
<tr>
<td>HR</td>
<td>0.981</td>
<td>0.966</td>
</tr>
<tr>
<td>BT</td>
<td>2.190</td>
<td>1.350</td>
</tr>
</tbody>
</table>

\( \checkmark \) Try to keep Temp at 36-37°C and HR 60-80 bpm to get better outcome?
Conclusion

- Therapeutic hypothermic strategy in E-CPR MAY NOT provide additional benefits in patient survival as we expected.
- ECMO offers enough protection??
- Goal-Directed Therapy may be another concept for further rescue.
Physiological changes during hypothermia. Severe specific events may occur during the three phases of hypothermia procedure. Time scale in hours is for illustrative purposes only. Andresen et al. Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine 2015 23:42
Thinking in different way

*Optimists see the opportunity in every difficulty*

- Churchill
Current Cooling Techniques

• Total body cooling: Surface cooling and intravenous heat exchange
• Slow (takes too long to hit target temp.), difficult to control (maintain target temp.), cumbersome
• Detrimental **systemic** effects; limited to ~32-33°C
  • Cardiac dysfunction – arrhythmias, arrest
  • Pulmonary infection
  • Electrolyte imbalance
  • Pharmacologic paralysis required to suppress shivering

• **Ineffective and impractical: cannot get cold enough**
  Cooling the body too much; not cooling the brain enough
Local hypothermia

- Cerebral hypothermia

Femoral approach

VA ECMO Circuit

Flow direction

Heat Exchange

TwinFlo BSD Hypothermia Circuit

Water Chiller and Temperature Controller

Pump Disposable

Pump Drive

Pump Console
Data Temperature profiles to 800min

- Delay to move TwinFlo
- Step 1: 9 degrees in 15 minutes
- Stable temp at 1:35 at 84 min after twinflo reposition

Rectal temp ~ 37°C
Nasal temp ~ 27°C
1st human trial
38 y/o urologist

- No bystander CPR
- Car accident at least 4 min EMT arrival
- VT → arrest → ECPR, at least 52 min
- Initial E1M1T1 → E1M4Vt after ECMO
- Selective cerebral hypothermia 11 hours later

- Back to work 1 month later

- Return to surgery 2 months later
1\textsuperscript{st} human trial
Hypothesis: brain ischemia tolerance 20 to 30 min
How to do? And how to rescue more?
Unsolved & debatable issues

0 Timing for call, timing for stop?
0 Hypothermia provides better protection in addition to ECPR?
0 Decompression offers rapid recovery
0 What is the policy for pressure or flow?
0 Brain vs heart

Waiting everyone’s effort – international cooperation

0 Controlled reperfusion for brain?
Interventional Cardiology Devices Market to Reach US$11.2 Billion by 2022 due to Increasing Incidence of Coronary Artery Diseases
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Global Oncology Drug Spending 2010–14

Source: IMS Health MIDAS, Dec 2014
Market Forecast

Source: IMS Health MIDAS, Dec 2014; IMS Health Market Prognosis, March 2015
Cancer Survival (All Ages, Races, Gender)

Suggestion

- Cancer marketing – development - increasing
  - 100 billion

- Cardiology marketing – development - declining
  - Total 150 billion

- Resuscitation 10 billion??

- International cooperation to explore the unknown field
Take home message in ECPR

- Outcomes depend on (1) expertise in ECMO team, (2) selection

- ECPR becomes another type of CPR, and future of resuscitation for better survival

- There are *known knowns* (things we know we know), *unknown knowns* (things we do not know), and more *unknown unknowns* (the ones we don’t know)

- Dare to dream for next innovation
Dare to Dream...

Thinking about a new chain of survival in the near and far future
Never Surrender!!

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• NTUH Cardiology

All cardiac residents, trained and in training
Non-survivors and survivors

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US CHEN

Slide modified from Ped CVS Dr. Tom Karl