21. Cerebrovascular time constant
What is cerebrovascular time constant?

✓ Time to fill cerebral arterial bed with blood volume after a sudden change in ABP during one cardiac cycle

\[ \tau = C_a \cdot CVR \] \[ \text{[s]} \]

\[ \frac{S_a \cdot \text{Amp}}{\text{Amp}_{\text{ABP}}} \cdot \frac{\text{meanABP}}{\text{meanCBFV} \cdot S_a} \]


Thanks to Dr. M. Kasprowicz
Thanks to Dr. M. Kasprowicz
Anova p<0.0006

- p=0.044
- p<0.02
- p<0.0002

τ [sec]

normocapnia  hypercapnia  hypocapnia

Thanks to Dr. M. Kasprowicz
Carotid Artery stenosis study: Material

1. 25 patients with ICA stenosis
   (20 males and 5 females, median age: 62 years)
   - 16 patients with unilateral ICA stenosis
     (median stenosis 84.5%, range 50-100% on one side)
   - 9 patients with bilateral ICA stenosis
     (median stenosis 95%, range 50-100% on both sides)

2. 11 healthy volunteers
   (8 males and 3 females, median age: 21 years)

Thanks to Dr.M.Kasprowicz
Response to changes in CO$_2$

normal subject

Thanks to Dr. M. Kasprowicz
Response to changes in CO\textsubscript{2} 
unilateral ICA stenosis

ANOVA, p<0.002

ANOVA, p<0.009

Thanks to Dr. M. Kasprowicz
Response to changes in CO$_2$ unilateral ICA stenosis

- p<0.004
- p<0.001
- p=0.001

Thanks to Dr. M. Kasprowicz

ipsilateral side vs. contralateral side

- Normocapnia
- Hypercapnia
- Hypocapnia

Comparison of $	au$ values: 0.14, 0.16, 0.18, 0.20, 0.22, 0.24, 0.26, 0.28
Response to changes in CO$_2$

bilateral ICA stenosis

ANOVA, $p=0.00002$

$p<0.00005$

$p<0.00002$

Thanks to Dr. M. Kasprowicz
Baseline: comparison of patients & controls

ANOVA, p=0.011

controls
contra
ipsi
bilateral

unilateral stenosis

Thanks to Dr. M. Kasprowicz
\( \tau \) and degree of stenosis

\[
R = -0.62 \quad p < 0.001
\]

Thanks to Dr. M. Kasprowicz
Cerebrovascular time constant: dependence on cerebral perfusion pressure and end-tidal carbon dioxide concentration

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Change in PaCO2 (at normal ICP and normal ABP), 0- hypocapnia, 1-normocapnia 2-hypercapnia. How ‘primary variables react to PaCO2?
Reduction of ABP

- ABP
- CPP
- FV
- ICP
- Ca
- CVRa
- TAUa
Haemorrhagic hypotension

ABP

FV

Ca

CVRa

TAUa
Arterial hypertension
SUMMARY LOOKS LIKE THAT:

ABP : TAU (CVR, Ca)

ICP : TAU (CVR, Ca)

PaCO2 : TAU (CVR, Ca)
HI – ABP drop - \( \tau \)

**T-test, dependent samples** \( p=0.000003 \)

<table>
<thead>
<tr>
<th>ABP [mm Hg]</th>
<th>Mean ±SE ±0.95 Conf. Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>baseline</td>
<td></td>
</tr>
<tr>
<td>ABP decrease</td>
<td></td>
</tr>
</tbody>
</table>

**T-test, dependent samples** \( p=0.000005 \)

<table>
<thead>
<tr>
<th>CPP [mm Hg]</th>
<th>Mean ±SE ±0.95 Conf. Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>baseline</td>
<td></td>
</tr>
<tr>
<td>ABP drop</td>
<td></td>
</tr>
</tbody>
</table>

**T-test, dependent samples** \( p=0.89 \)

<table>
<thead>
<tr>
<th>( \tau ) [sec]</th>
<th>Mean ±SE ±0.95 Conf. Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>baseline</td>
<td></td>
</tr>
<tr>
<td>ABP drop</td>
<td></td>
</tr>
</tbody>
</table>

Thanks to Dr. M. Kasprowicz.
Arterial hypotension - TBI

- ABP
- CPP
- FV
- ICP
- Ca
- CVR
- CVRa
- TAU
- TAUa
HI - Hypocapnia - $\tau$

T-test, dependent samples $p=0.000075$

Thanks to Dr. M. Kasprowicz
Plataeu waves - τ

Friedman Anova  p<0.62

Thanks to Dr. M. Kasprowicz
Individual tracing: plateau wave

- ABP
- CPP
- FV
- ICP
- Ca
- CVR
- CVRa
- TAU
- TAUa
Stroke- Freiburg

• 44 patients tested 1st day after recanalization and day 5th after recanalization (2)

• NIH score, infarct volume, outcome (mRelkin score)

Thanks to Dr. M. Reinhard
Thanks to Dr. M. Reinhard

R = 0.49; p = 0.0025

[Graph showing the relationship between TAU [s] and Infarct size]
Thanks to Dr. M. Reinhard
Thanks to Dr. M. Reinhard
SAH study: Material

1. 13 patients with vasospasm after SAH
   (7 males and 6 females, median age: 48 years)

2. cerebral vasospasm was detected by TCD
   mean CBFV in MCA>120 [cm/s]
   Lindegaard ratio (CBFVMCA/CBFVICA)>3
   and confirmed by angiography

3. all patients received triple-H therapy
Thanks to Dr. M. Kasprowicz
Thanks to Dr. M. Kasprowicz
TAU is shorter in PICA than in MCA – thanks to Prof. M. Reinhard and Dr. M. Kasprowicz.
Messages to take home:

• TAU conceptually shows how fast brain arterial blood volume settles after step change in ABP
• It has units! Therefore comparison between patients is possible
• TAU (CFF) decreases with hypercapnia and increases with hypocapnia
• TAU (CFF) increases in arterial hypotension
• TAU (CFF) decreases during vasospasm
• TAU (CFF) is longer in diabetic patients?
• TAU (CFF) increases with infarct size in patients after stroke?

All findings should be verified with PFF Model