Detection of Free Flap Pedicle Thrombosis by Infrared Surface Temperature Imaging

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Nothing to disclose

INTRODUCTION

- The ideal monitoring method
  - Non-invasive, reliable, continuous, accurate
  - Easy to use even for the inexperienced personnel
  - Inexpensive, provide real-time information
  - No single monitoring technique has fulfilled all requirements

(Heden et al. 1985, Jones 1988, Udesen et al. 2000, Yuen and Feng 2000, Kamolz et al. 2002, Setala et al. 2004, Hölzle et al. 2006, Repez et al. 2008)

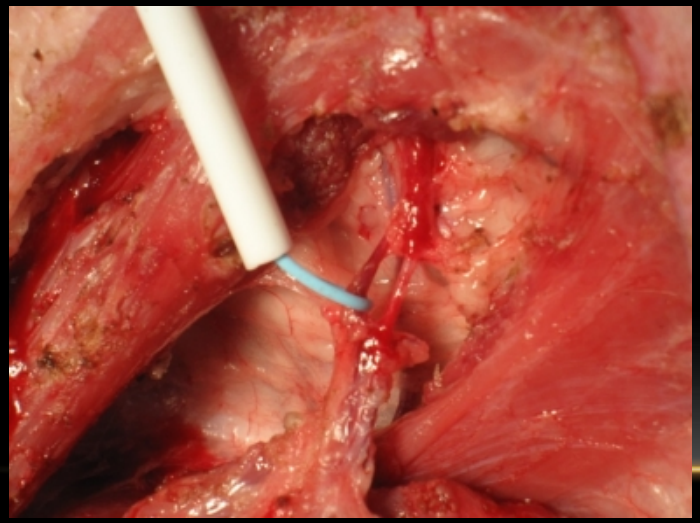
- Clinical observation is still the gold standard of flap assessment

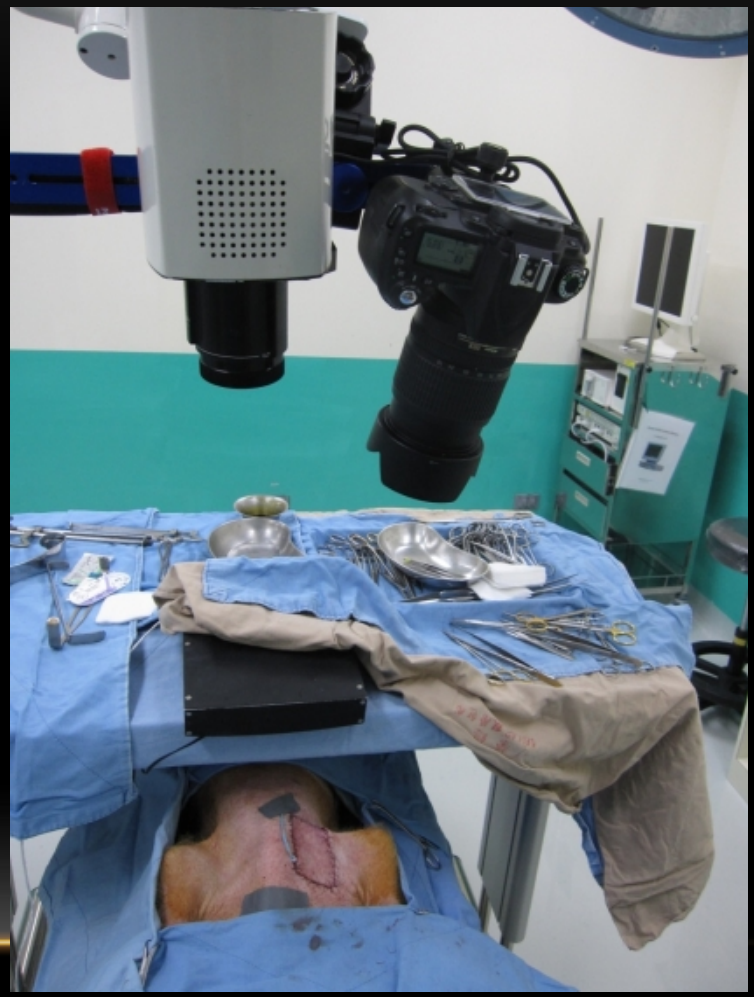
(Neligan 1993, Hirigoyen et al. 1995)

OBJECTIVES

- To clarify the relationship between the free flap surface temperature change and vascular pedicle thrombosis.
- To develop surface temperature parameter for free flap monitoring

MATERIAL AND METHOD – ANIMAL STUDY

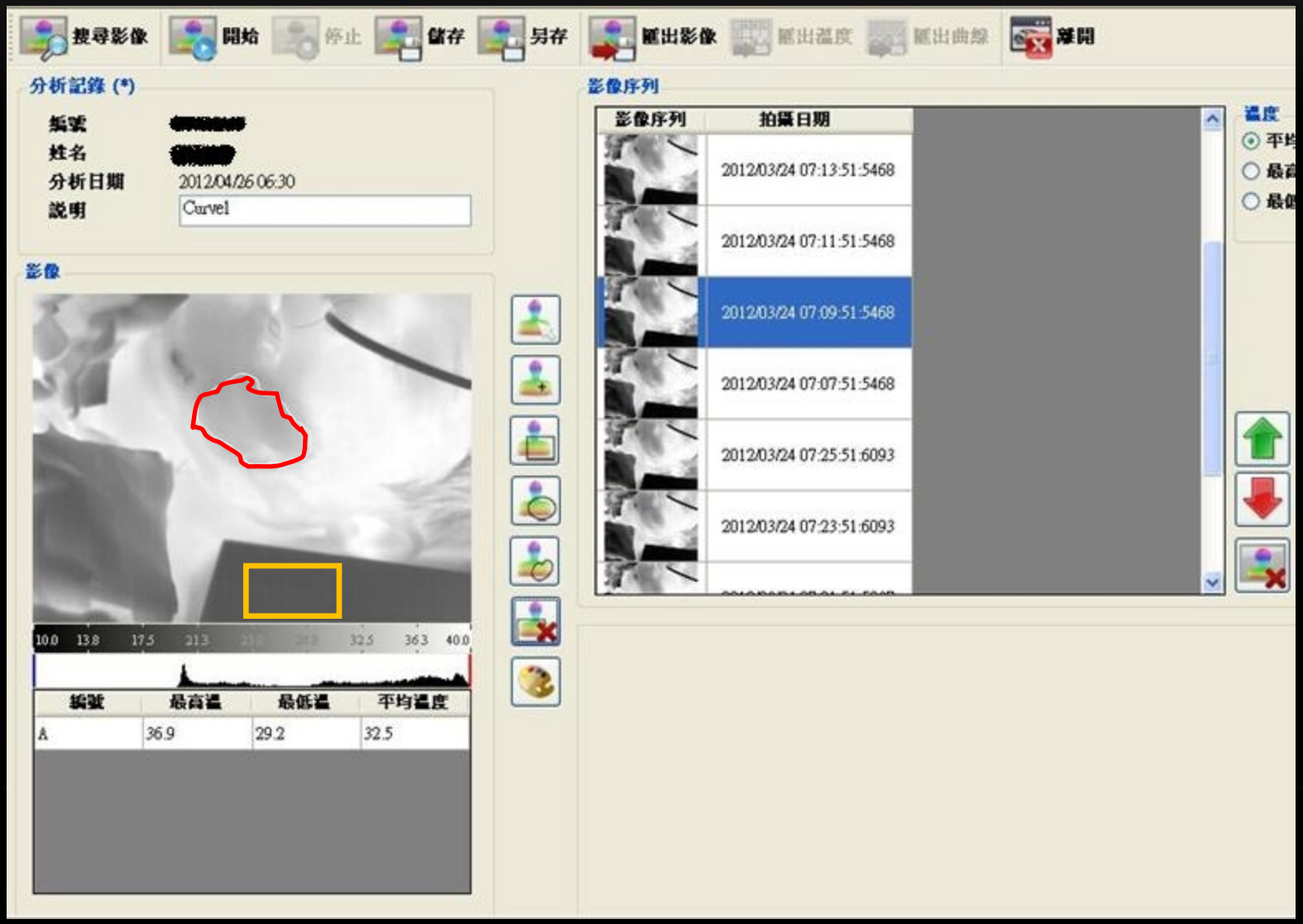




MATERIAL AND METHOD – HUMAN STUDY

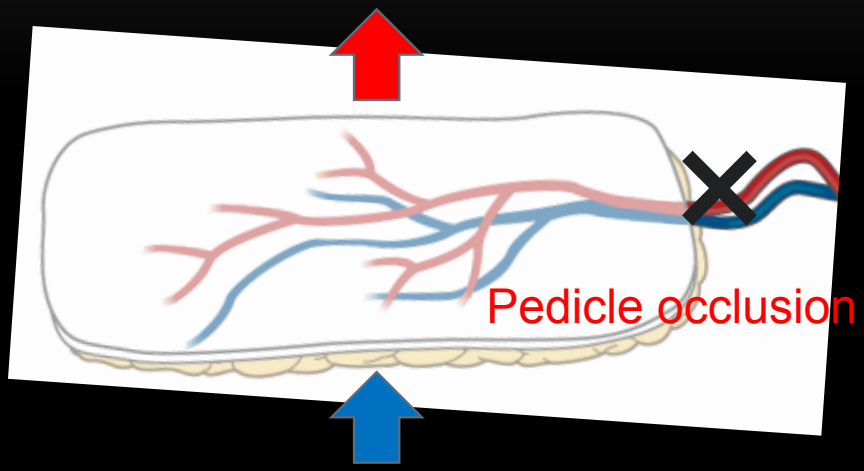
- Those patients who underwent free flap reconstruction surgery by PS doctor at VGHTPE from 2012/3/1 to 2013/2/28, and only non-buried flap was included. (n=21).
- Upon arrival to the ICU for postoperative management, free flap temperature (Ts) was monitored by IR imaging camera in 2-minute interval; room temperature (Tr), and human body core temperature (Tc) were also recorded for 24 hours. Simultaneous presence of Doppler signals were also recorded.

MATERIAL AND METHOD – HUMAN STUDY



PREDICTION OF FLAP SURFACE TEMPERATURE AFTER PEDICLE OCCLUSION

Heat convection: $Q_2=hA(Ts-Tr)$



Heat conduction: $Q_1=kAL^{-1}(Tc-Ts)$

Q: heat
h: air convection constant
A: flap surface area
Ts: flap surface temperature
Tr: room temperature
k: flap conduction constant
L: flap thickness
Tc: core temperature

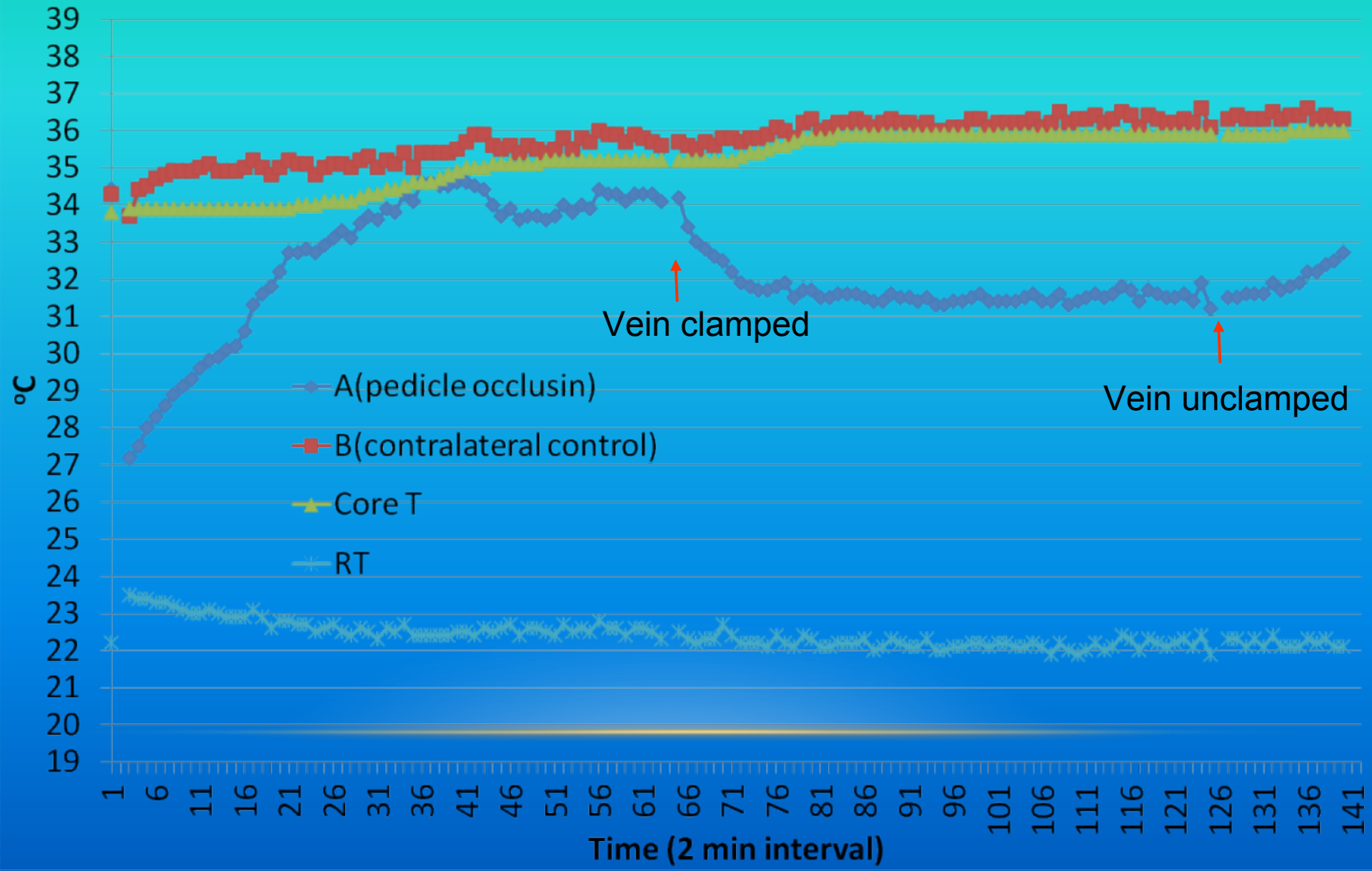
Ts will stabilized when $Q_1 = Q_2$

$kAL^{-1}(Tc-Ts) = hA(Ts-Tr)$

$Ts = k(hL+k)^{-1}Tc + hL(hL+k)^{-1}Tr$

$Ts = aTc + bTr$

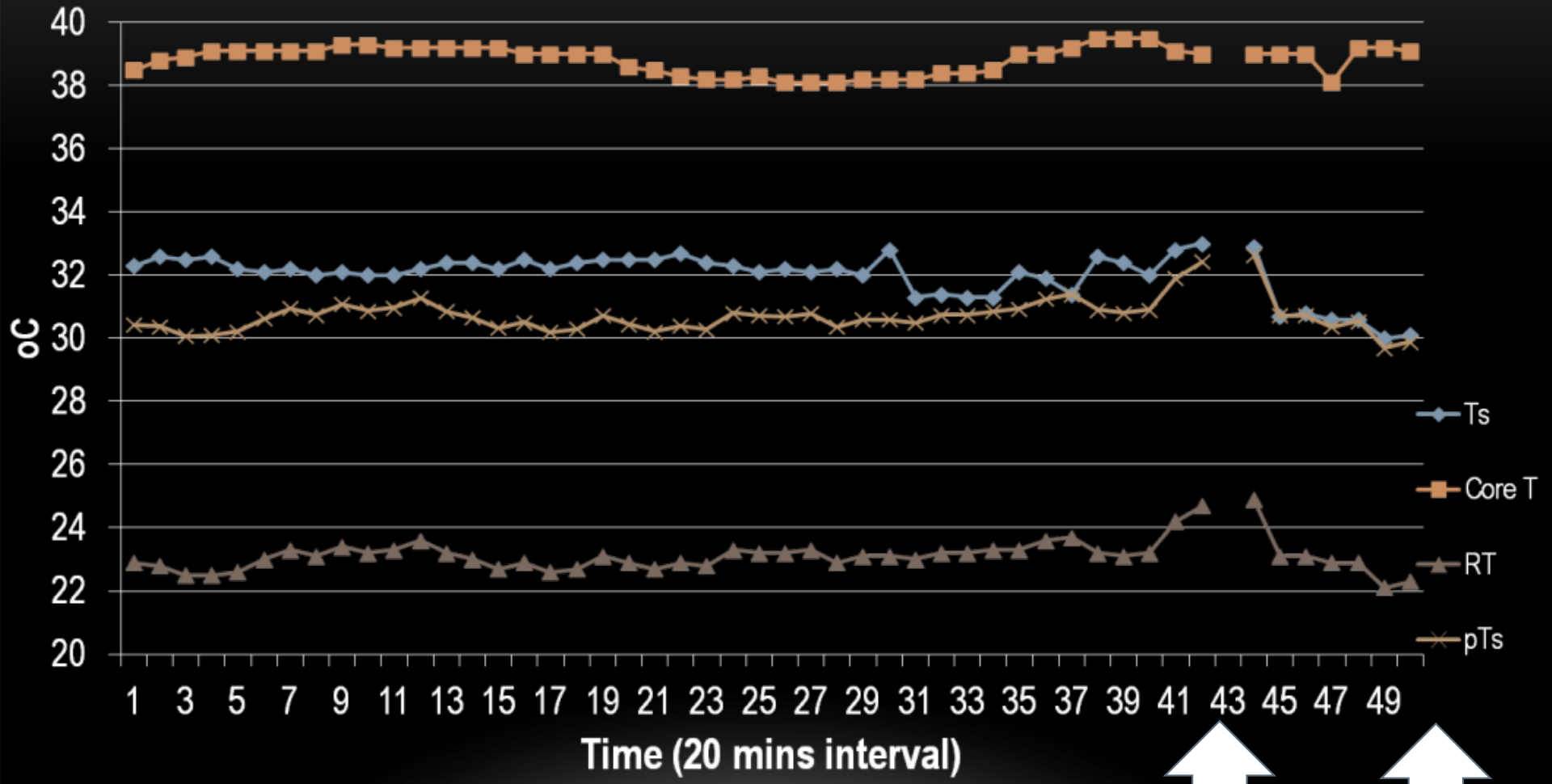
IR SURFACE TEMPERATURE TRACING –ANIMAL STUDY



RESULTS FOR HUMAN STUDY

- Total patients of flap with external skin exposure were 21 cases (Male:19 Female:2)
- Average age was 51.9 years-old (19~69)
- 20 flaps were for head and neck reconstruction; 1 flap for limb reconstruction.
- 2 of 21 cases suffered from venous thrombosis(9.5%). One flap was total failure (4.7%).

Case 1 of venous thrombosis



ICU nurse called duty R

Send patient to OR

MULTIPLE LINEAR REGRESSION FOR FLAP

- Surface Temperature prediction

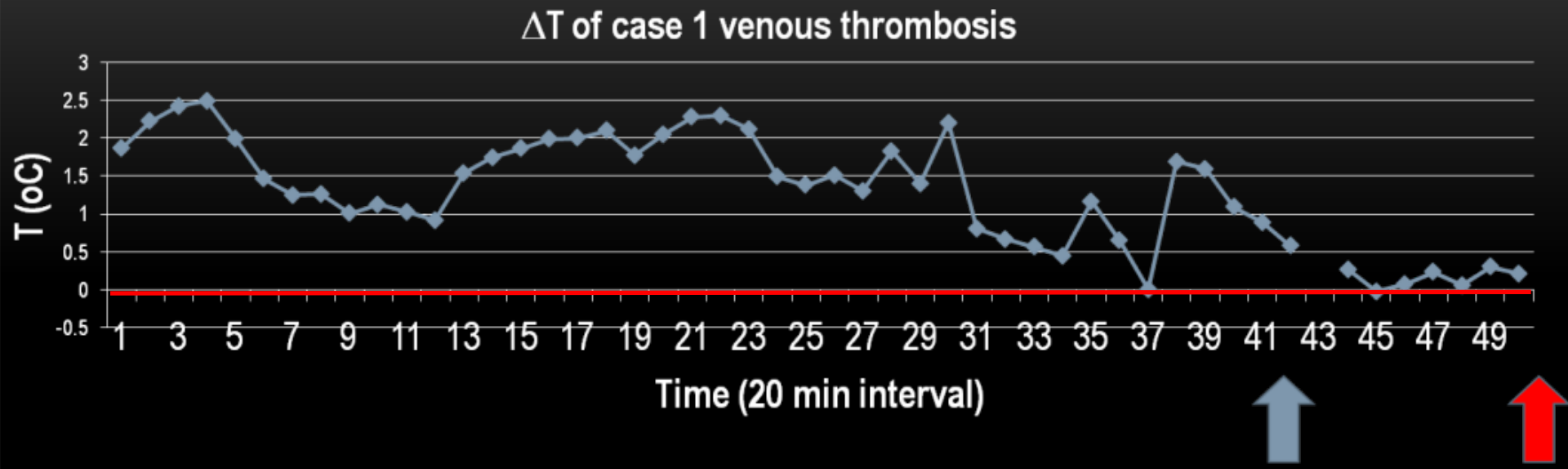
  With flap pedicle occlusion

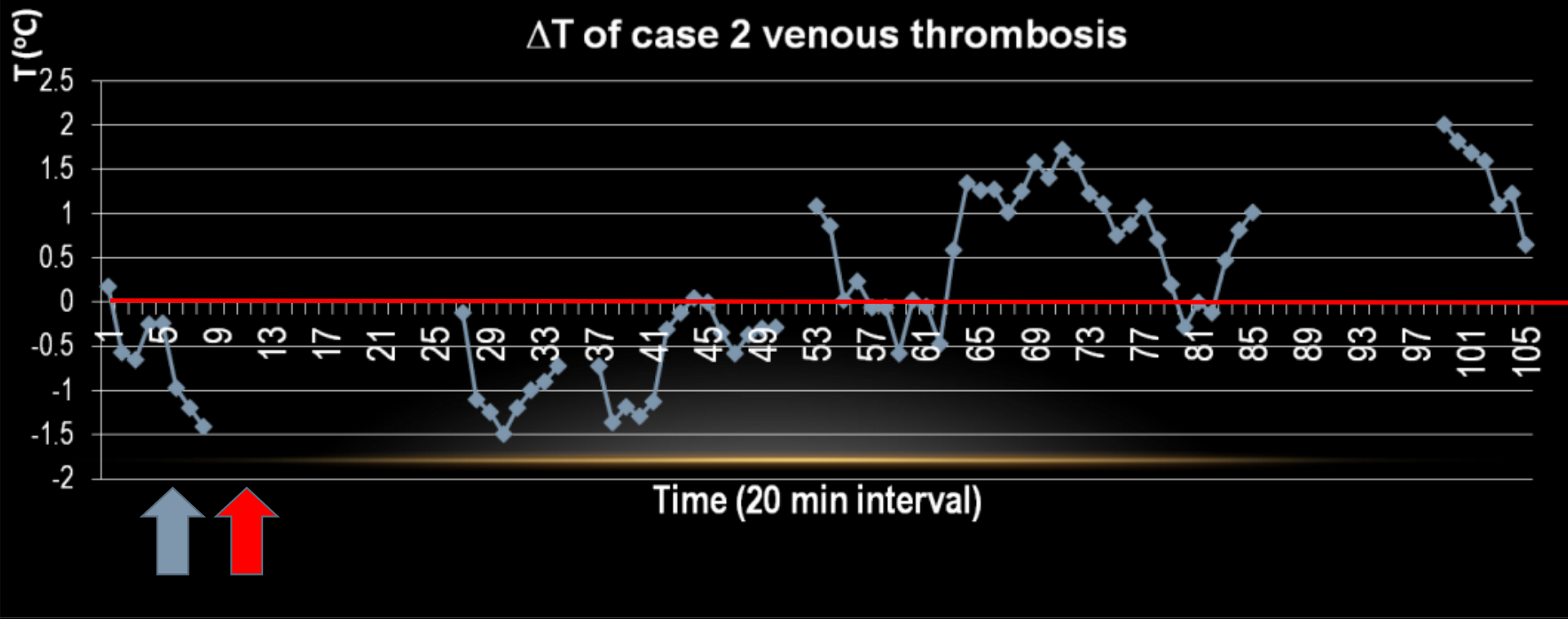
  Stabilized flap surface temperature will be

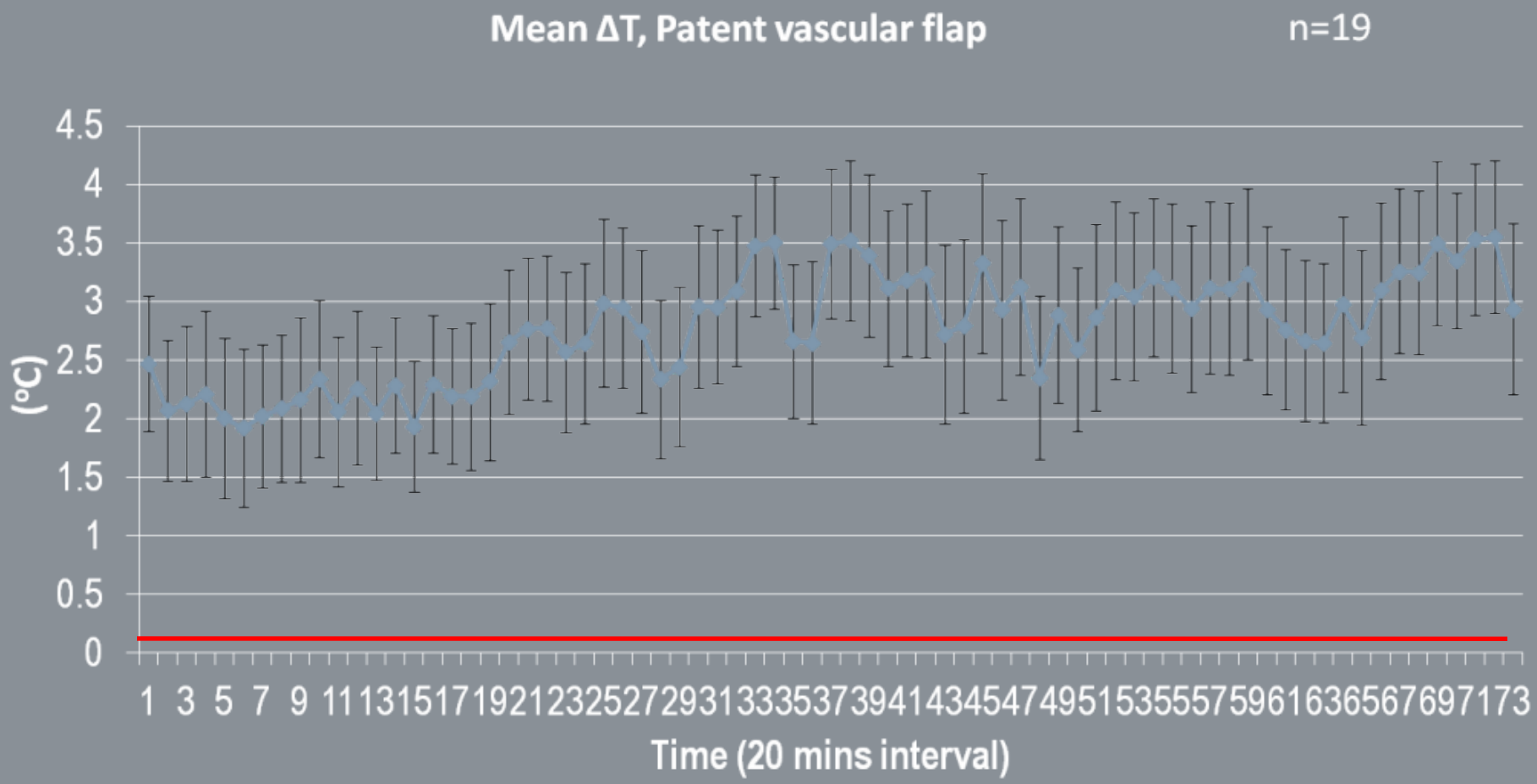
  In animal study $Ts = 0.66Tc + 0.40Tr$ $R^2 = 1.00$

  In human study $Ts = 0.16Tc + 1.06Tr$ $R^2 = 0.456$

- $\Delta T = Ts$– predicted stabilized Ts


ΔT of case 1 venous thrombosis
T (oC)
3
2.5
2
1.5
1
0.5
0
-0.5
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47 49
Time (20 min interval)


ΔT of case 2 venous thrombosis
T (°C)
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
1 5 9 13 17 21 25 29 33 37 41 45 49 53 57 61 65 69 73 77 81 85 89 93 97 101 105
Time (20 min interval)



Total ΔT (Ts- pred Ts) in patent vascular flap were 1072

ΔT in patent vascular flap < 0 C= 213

False positive rate: 19.8% (213/1072) → Specificity: 80.2%

DISCUSSION

- Factors influence flap surface-temperature
  - Room temperature
  - Core temperature
  - Cutaneous blood flow
- To use a physical formula to predict the flap surface temperature with room temperature and core body temperature.

  In animal study: $Ts = 0.66Tc + 0.40Tr;\ R^2 = 1.00$

  In the human study: $Ts = 0.16Tc + 1.06Tr;\ R^2 = 0.456$
- In the future, we may need more venous thrombosis case numbers to correct to the predictor parameter (**ΔT**).

CONCLUSION

- Based on our animal and human study, stabilized flap surface temperature after pedicle thrombosis may be predicted simply by core and room temperature, and may be used to predict flap pedicle thrombosis.
- In human study, with patent vascular pedicle, the difference between the flap surface temperature (Ts) and the predicted one (pred. Ts) had a high specificity to predict flap pedicle thrombosis . However, It needs further study for better interpretation.