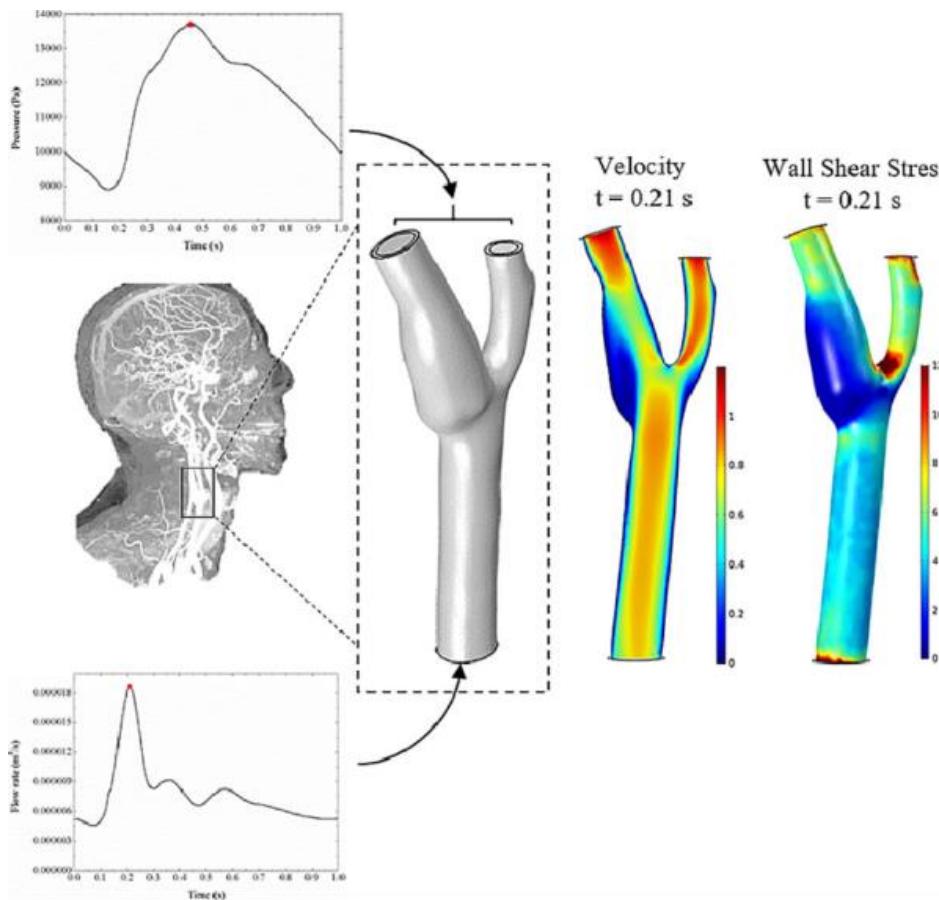


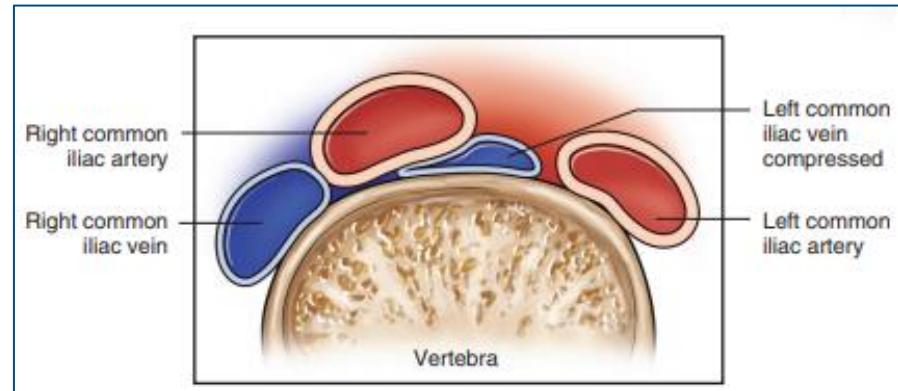
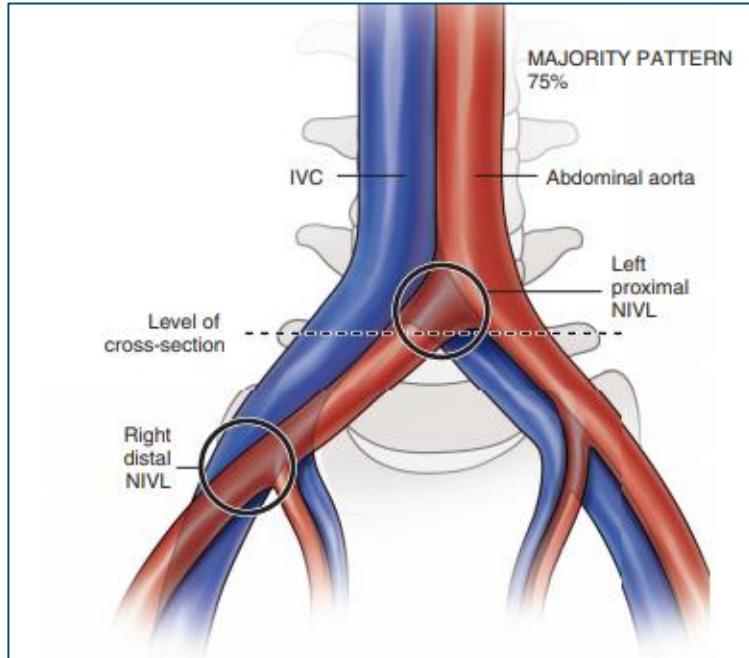
計算流體力學在醫學上的應用 (Computational Fluid Dynamics , CFD)



生醫光機電研究所
黃豪銘教授

Iliac vein compression syndrome (May- Turner syndrome)髂靜脈壓迫症候群

- Iliac vein compression syndrome (May- Turner syndrome)髂靜脈壓迫症候群
 - Lower limbs swelling, heaviness, varicose vein, soreness, ulcer, claudication, thrombosis...
 - Diagnosis : phleborheography(靜脈血流檢查圖), IVDSA (數位減像靜脈血管攝影), CT with 3D reconstruction
 - Treatment : surgery, anticoagulation, angioplasty and stenting

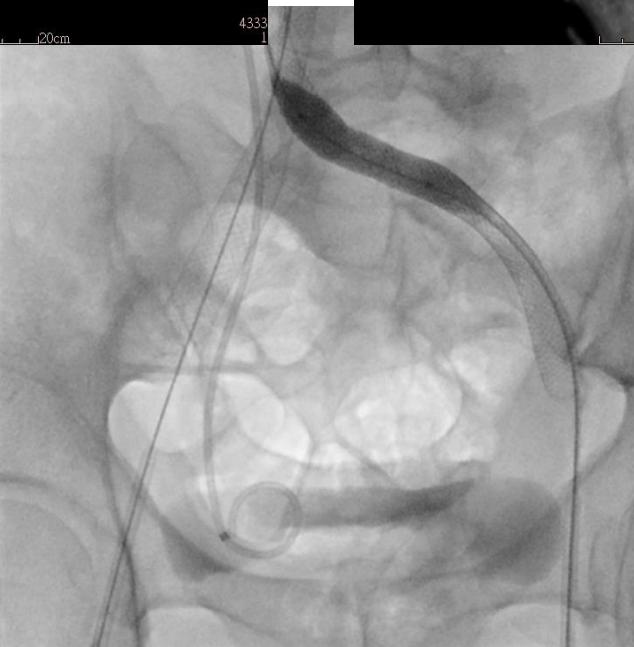
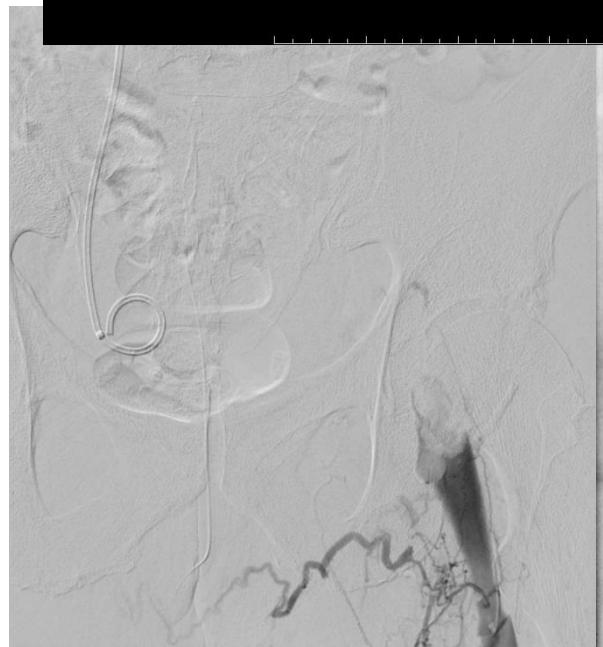
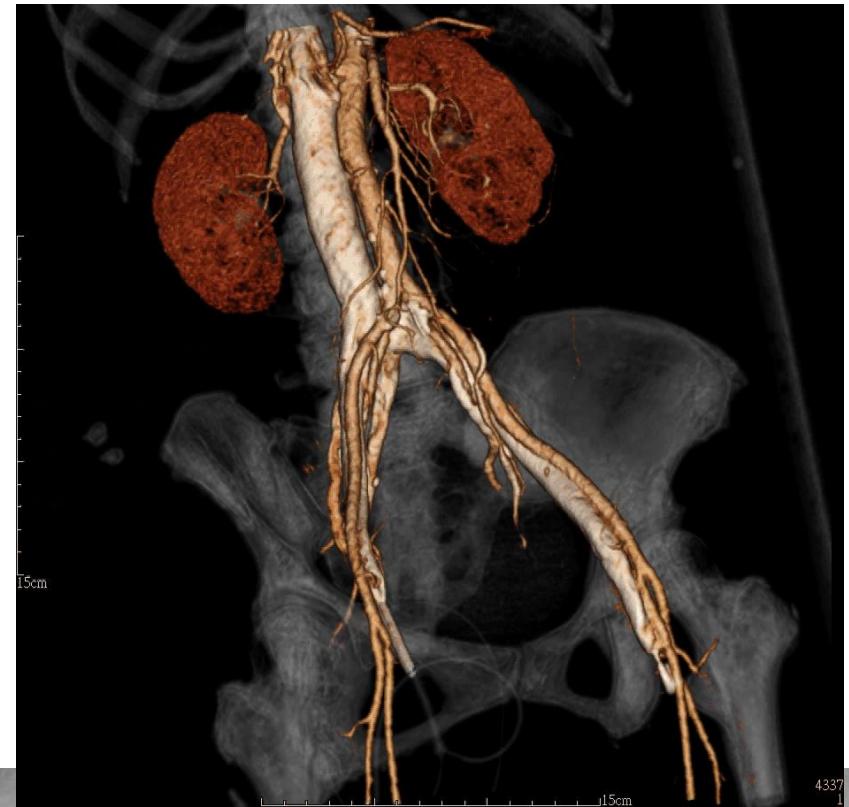
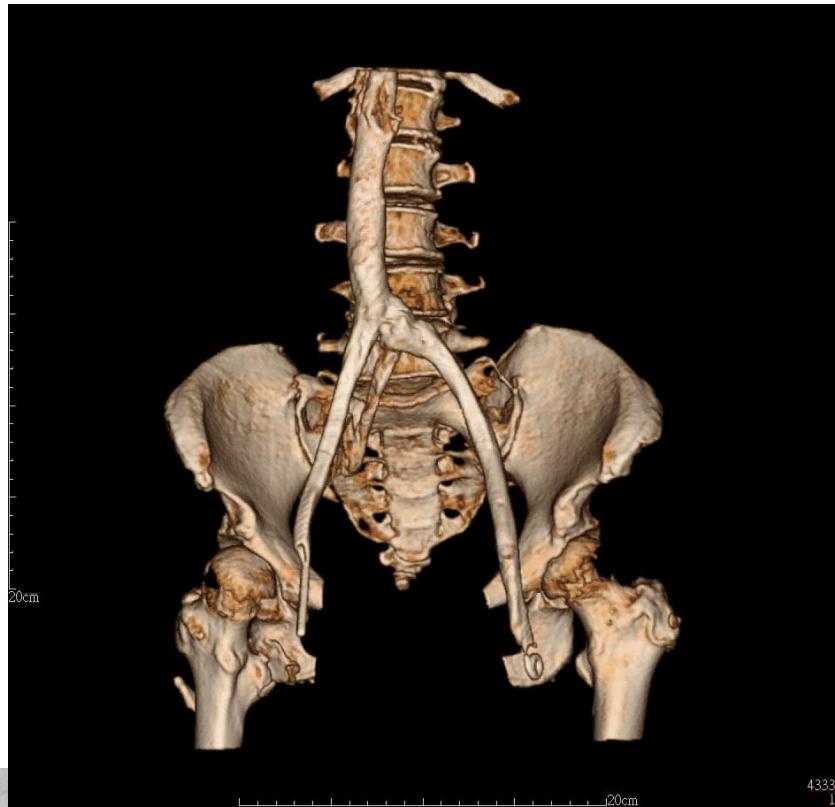


Iliac vein compression syndrome (May- Thurner syndrome)髂靜脈壓迫症候群

- Iliac vein compression syndrome (May- Thurner syndrome)髂靜脈壓迫症候群



- Lower limbs swelling, heaviness, varicose vein, soreness, ulcer, claudication, thrombosis...
- Diagnosis : phleborheography(靜脈血流檢查圖), IVDSA (數位減像靜脈血管攝影), CT with 3D reconstruction
- Treatment : surgery, anticoagulation, angioplasty and stenting



流力壓就像塞車，不同的路段會有不同的壓力

如果每分鐘進去的跟每分鐘出來的會一樣多，那麼車道變寬，車速就會降低，反之亦然



造成塞車壓力的原因



交流道闖道口



收費站



自由時報

道路彎曲



車道縮減

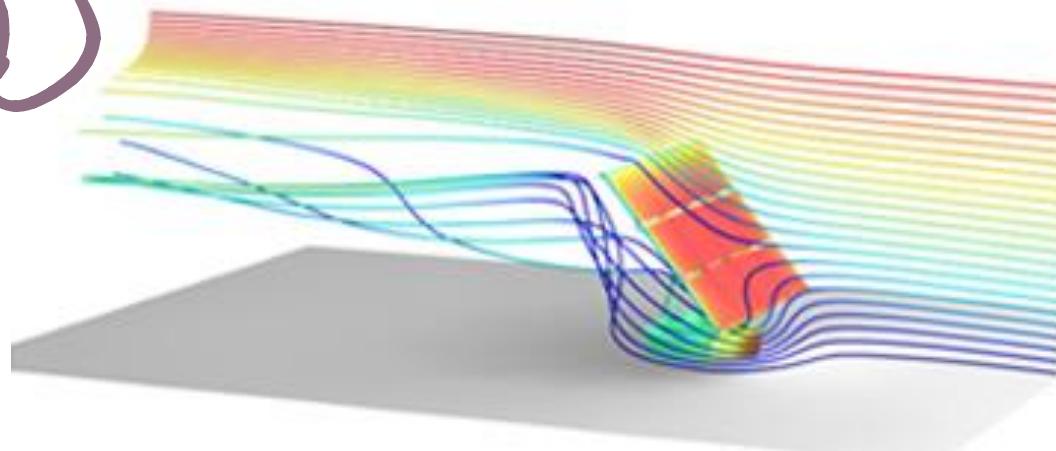
計算流體力學 (Computational Fluid Dynamics , CFD)

離散化模型

模擬流體的模型

- 有限體積法 (Finite Volume Method, FVM)
- 有限差分 (Finite Difference Method, FDM)
- 邊界元法 (boundary element method)
- 有限元法 (Finite Element Method, FEM)

最常見)



What is FEM ?

- FEM is a mathematical method providing **theoretic basis** for engineering problems
- FEM is a **numerical simulation** method for solving structural problems with complex geometrical shapes and material properties .

Stress and Strain

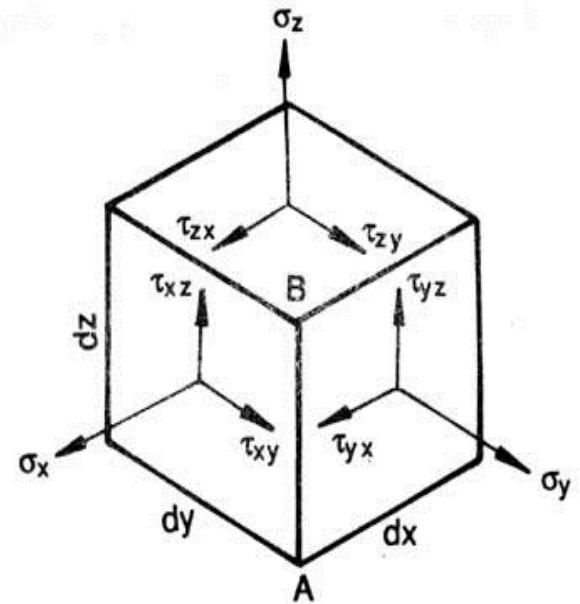
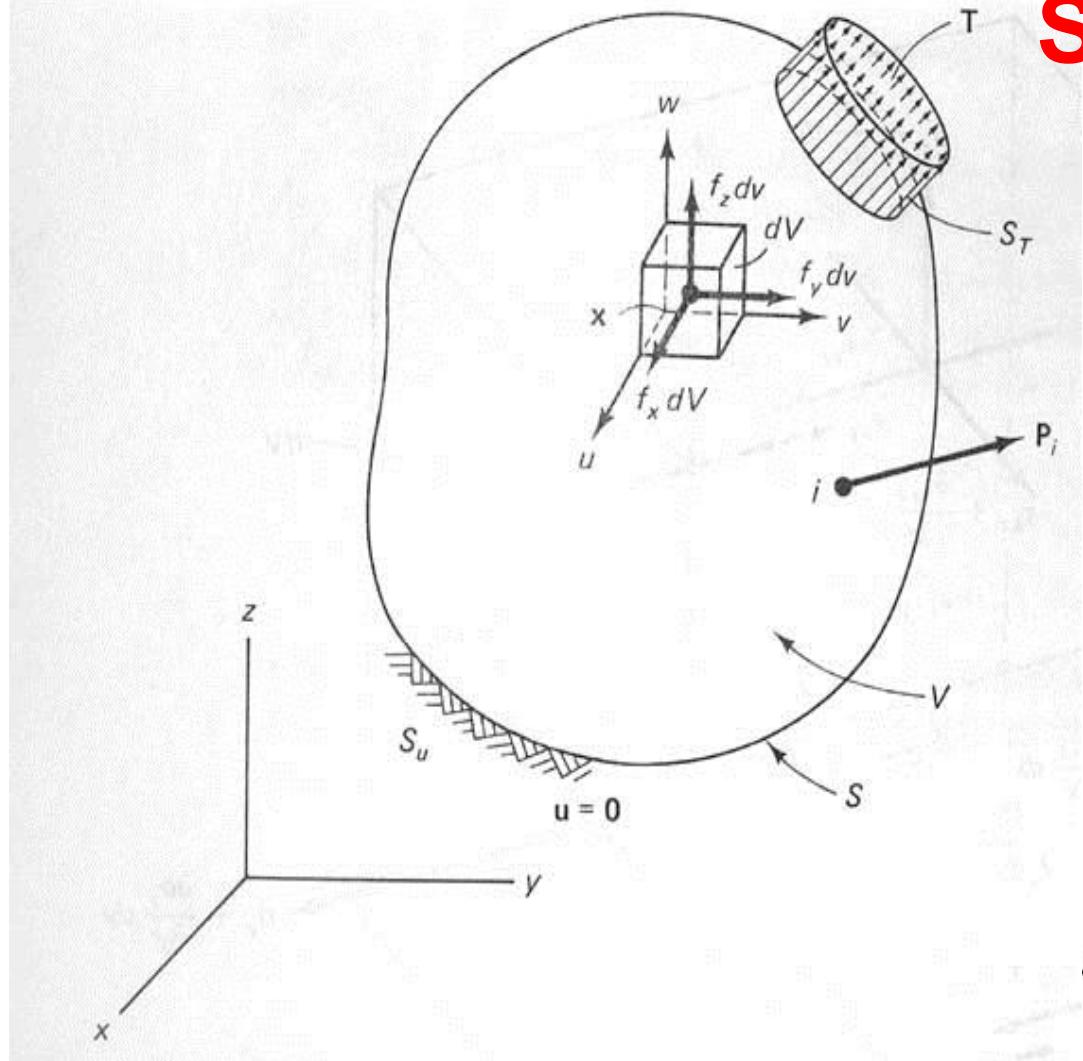


FIGURE 1.1 Elemental cube subject to stresses in Cartesian coordinates.

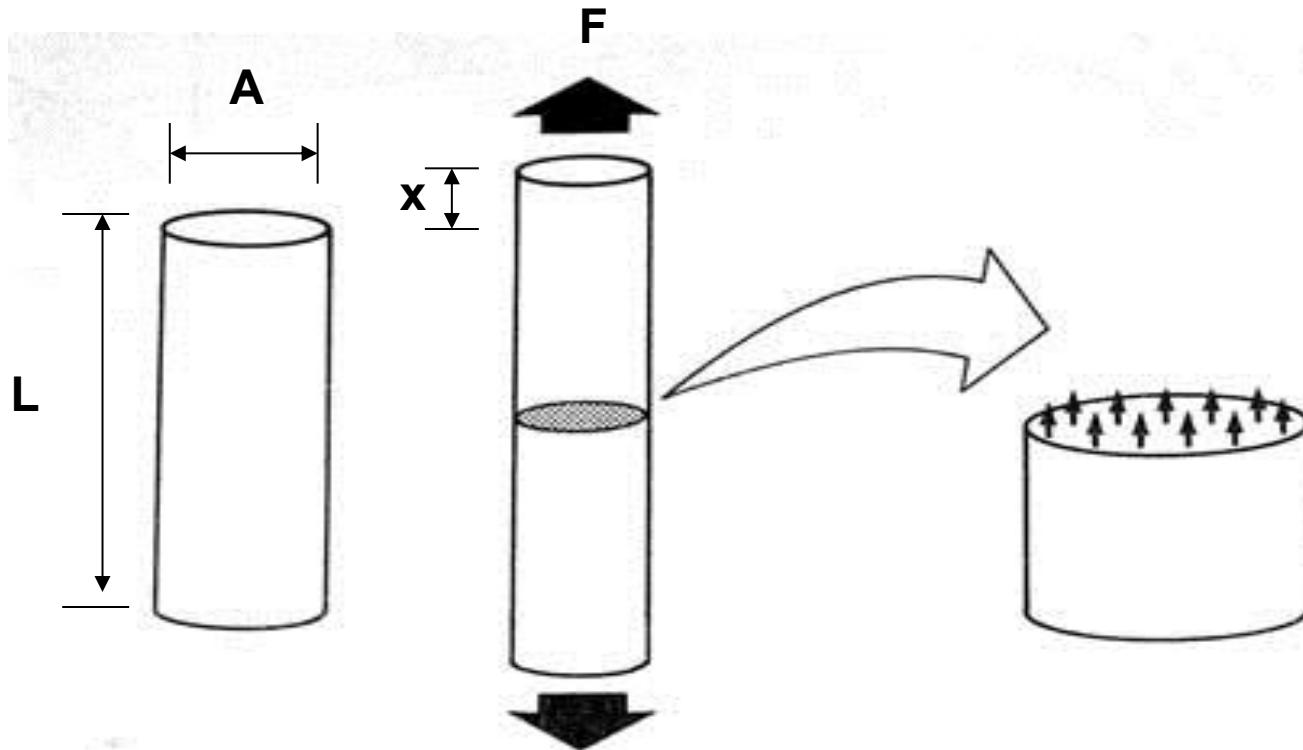
Stress and Strain

$$\sigma = \frac{F}{A}$$

σ : 應力
F: 外力
A: 截面積

$$\epsilon = \frac{x}{L}$$

ϵ : 應變
L: 原長
x: 變形量



$$\epsilon_x = \frac{1}{E} [\sigma_x - \nu(\sigma_y + \sigma_z)]$$

$$\epsilon_y = \frac{1}{E} [\sigma_y - \nu(\sigma_z + \sigma_x)]$$

$$\epsilon_z = \frac{1}{E} [\sigma_z - \nu(\sigma_x + \sigma_y)]$$

$$\gamma_{xy} = \frac{2(1 + \nu)}{E} \tau_{xy}$$

$$\gamma_{yz} = \frac{2(1 + \nu)}{E} \tau_{yz}$$

$$\gamma_{zx} = \frac{2(1 + \nu)}{E} \tau_{zx}$$

Integration

用積分的概念

每一小格都代公式

疊代運算

網格化

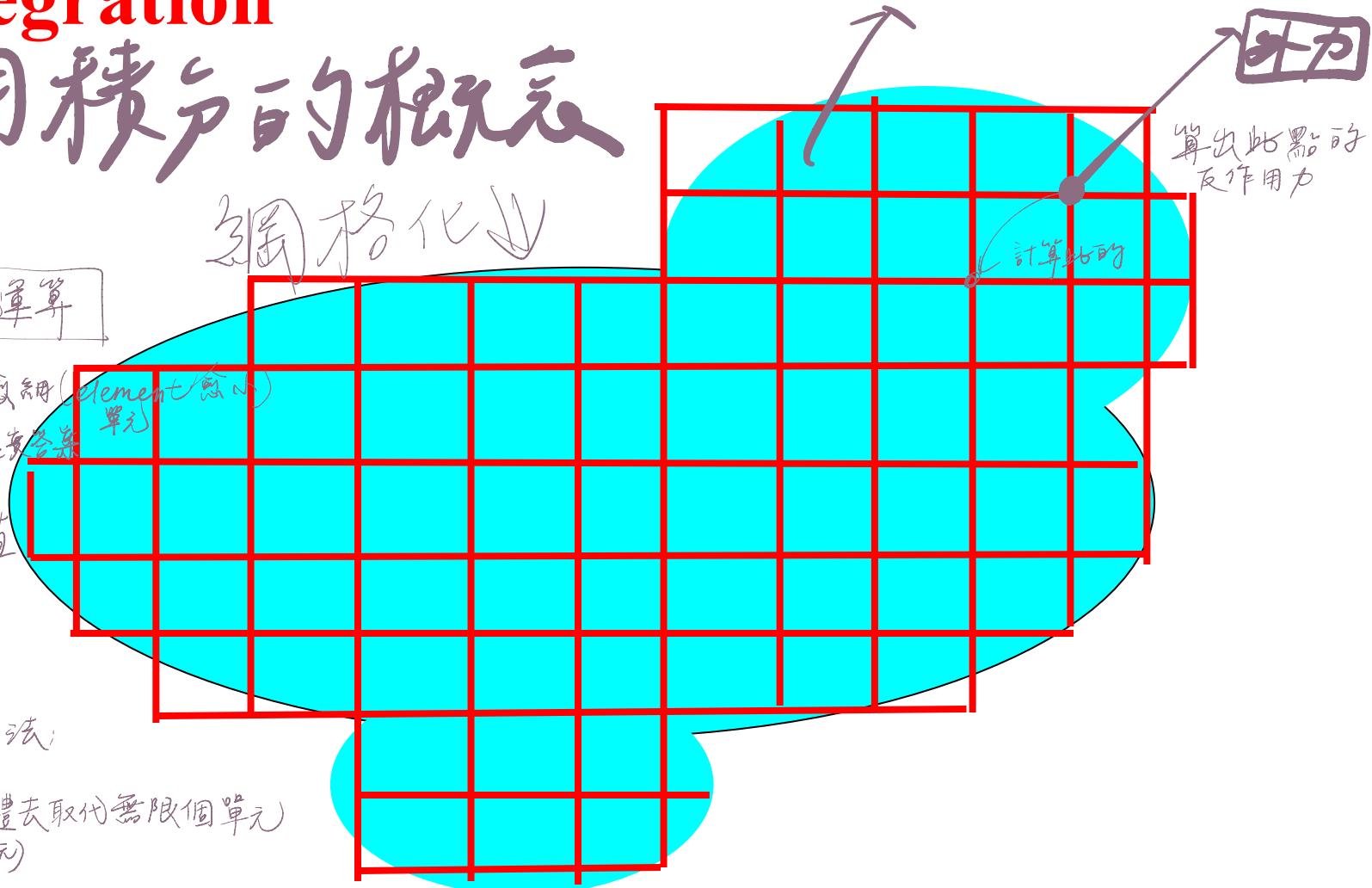
切的彎綿 (element/單元)
愈近於真實答案

當誤差 < 要值

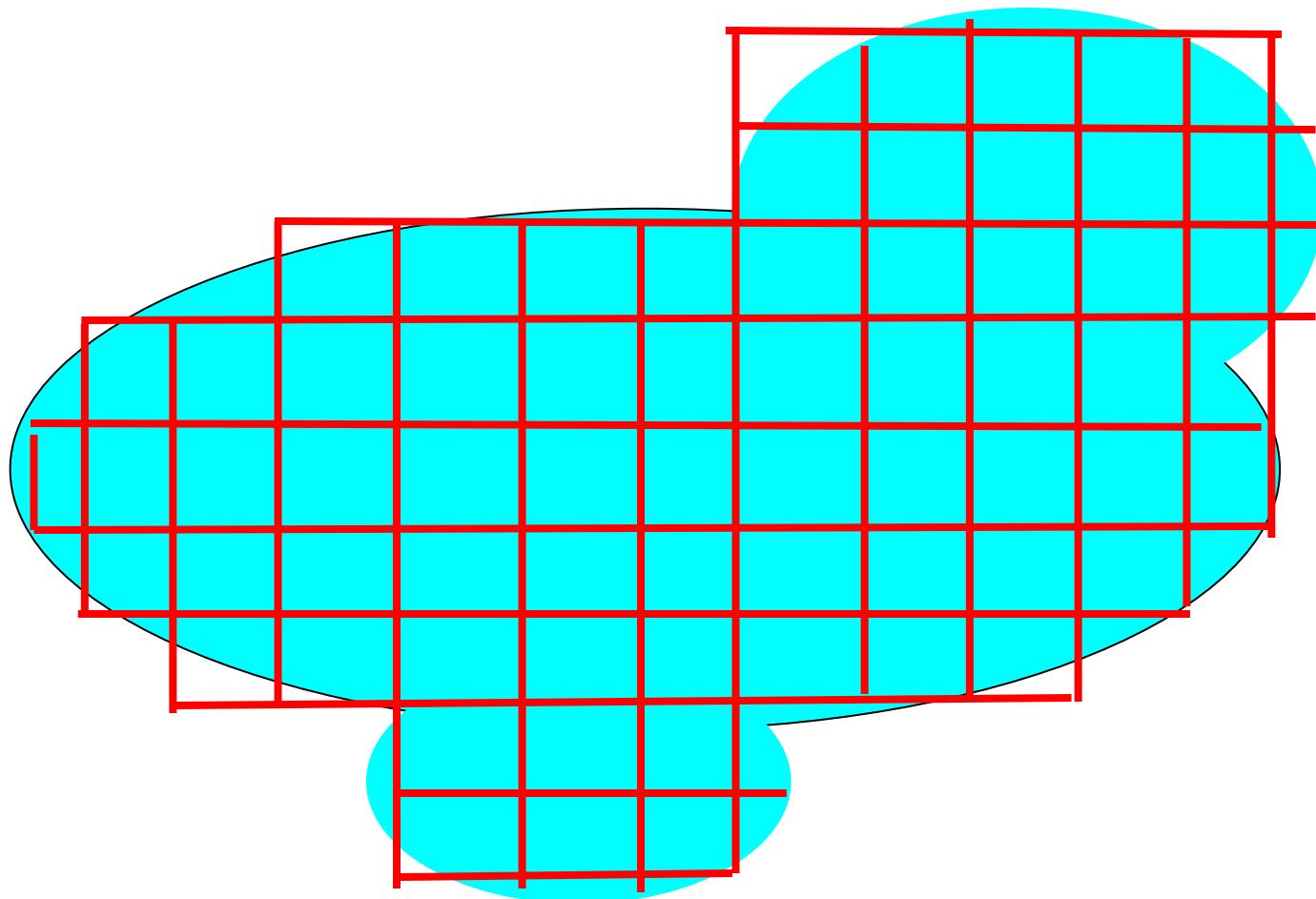
→ 收斂

(單體)
有限元素方法

→ 有限的單體去取代無限個單元
(元)



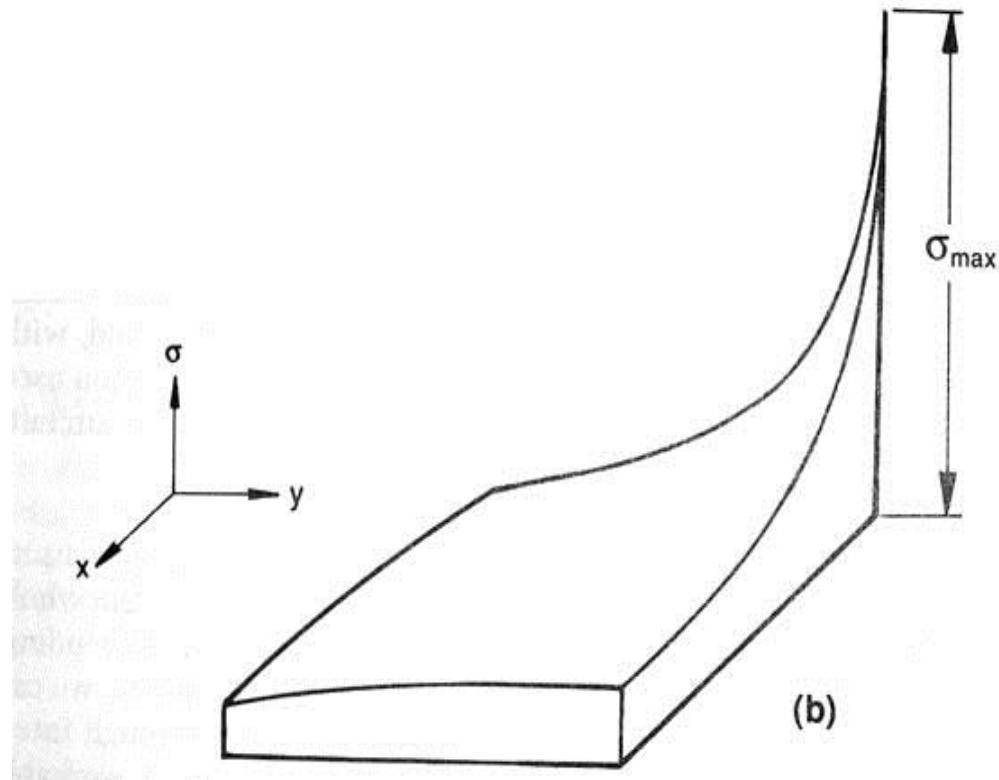
Integration



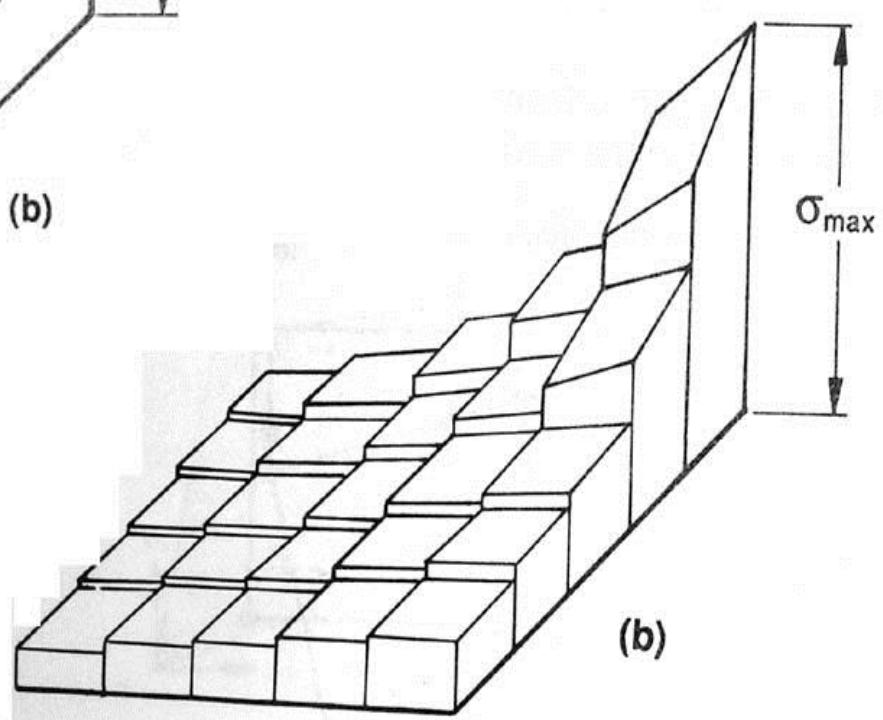
2D- finite element method

FEM



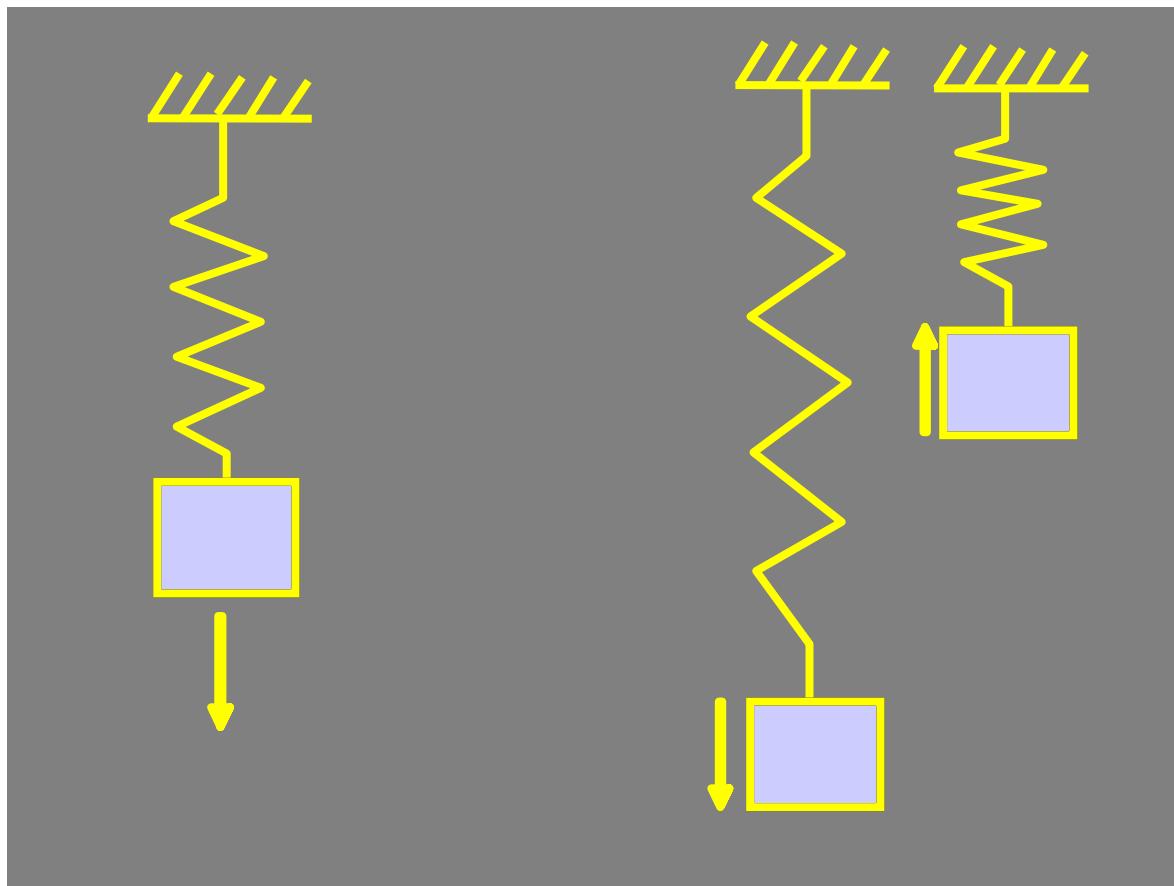


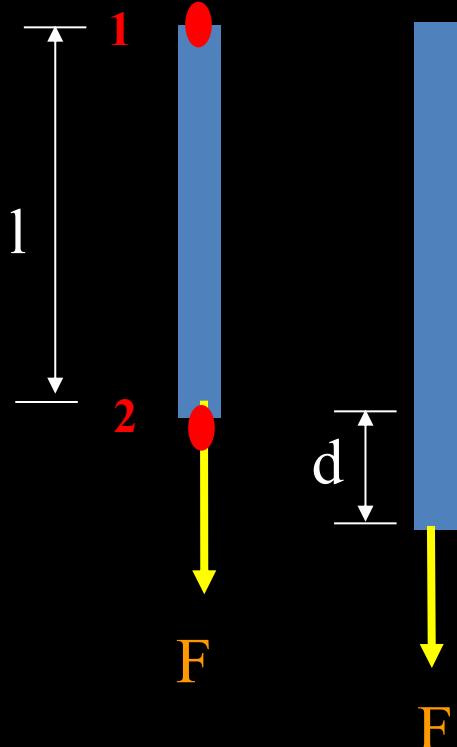
(b)



(b)

Hook's law: $F = k d$





$$\sigma = E \varepsilon$$

$$\sigma = \frac{F}{A}$$

$$\varepsilon = \frac{d}{l}$$

$$\frac{F}{A} = E \frac{d}{l}$$

$$F = \frac{AE}{l} d$$

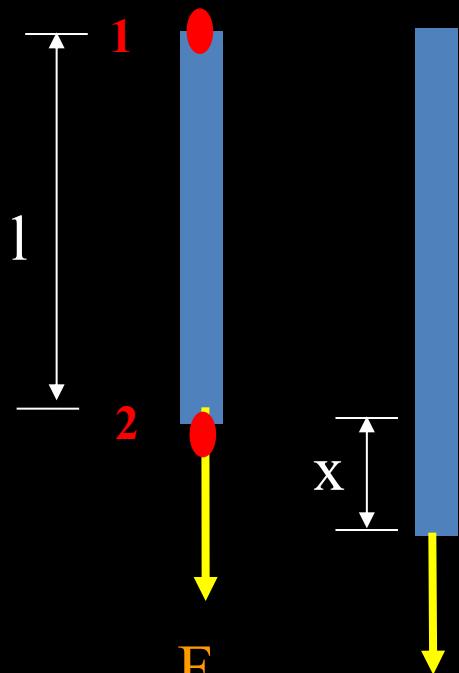
Hook's law: $F = k d$ $k = \frac{AE}{l}$

$$\begin{cases} Y_1 = 2X_1 + 4X_2 \\ Y_2 = 5X_1 + 3X_2 \end{cases}$$

$$\begin{Bmatrix} Y_1 \\ Y_2 \\ 0 \\ 0 \end{Bmatrix} = \begin{Bmatrix} 2 & 4 & 0 & 0 \\ 5 & 3 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{Bmatrix} \begin{Bmatrix} X_1 \\ X_2 \\ 0 \\ 0 \end{Bmatrix}$$

$$\begin{Bmatrix} Y_1 \\ Y_2 \end{Bmatrix} = \begin{Bmatrix} 2 & 4 \\ 5 & 3 \end{Bmatrix} \begin{Bmatrix} X_1 \\ X_2 \end{Bmatrix}$$

$$\begin{Bmatrix} 0 \\ 0 \\ Y_1 \\ Y_2 \end{Bmatrix} = \begin{Bmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 2 & 4 \\ 0 & 0 & 5 & 3 \end{Bmatrix} \begin{Bmatrix} 0 \\ 0 \\ X_1 \\ X_2 \end{Bmatrix}$$



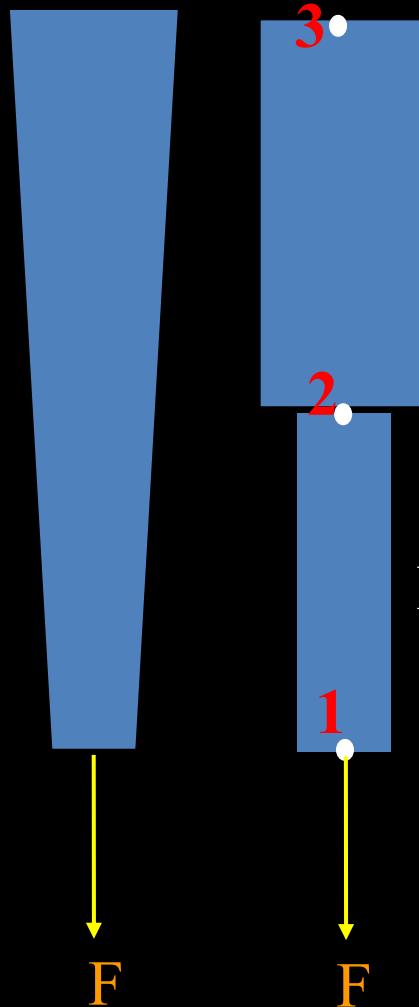
$$d_1 = x_1 - x_2$$

$$d_2 = x_2 - x_1 = -x_1 + x_2$$

$$\begin{Bmatrix} d_1 \\ d_2 \end{Bmatrix} = \begin{bmatrix} 1 & -1 \\ -1 & 1 \end{bmatrix} \begin{Bmatrix} X_1 \\ X_2 \end{Bmatrix}$$

$$F = \frac{AE}{l} d$$

$$\begin{Bmatrix} F_1 \\ F_2 \end{Bmatrix} = \frac{AE}{l} \begin{Bmatrix} d_1 \\ d_2 \end{Bmatrix} = \frac{AE}{l} \begin{bmatrix} 1 & -1 \\ -1 & 1 \end{bmatrix} \begin{Bmatrix} X_1 \\ X_2 \end{Bmatrix}$$



Element a

$$[K_b] = \frac{A_2 E}{l} \begin{bmatrix} 2 & 3 \\ 1 & -1 \\ -1 & 1 \end{bmatrix} \begin{matrix} 2 \\ 3 \end{matrix}$$

$$= \frac{A_2 E}{l} \begin{bmatrix} 0 & 0 & 0 \\ 0 & 1 & -1 \\ 0 & -1 & 1 \end{bmatrix} \begin{matrix} 2 \\ 3 \end{matrix}$$

(2)

$$[K_a] = \frac{A_1 E}{l} \begin{bmatrix} 1 & 2 \\ 1 & -1 \\ -1 & 1 \end{bmatrix} \begin{matrix} 1 \\ 2 \end{matrix}$$

$$= \frac{A_1 E}{l} \begin{bmatrix} 1 & -1 & 0 \\ -1 & 1 & 0 \\ 0 & 0 & 0 \end{bmatrix} \begin{matrix} 1 \\ 2 \end{matrix}$$

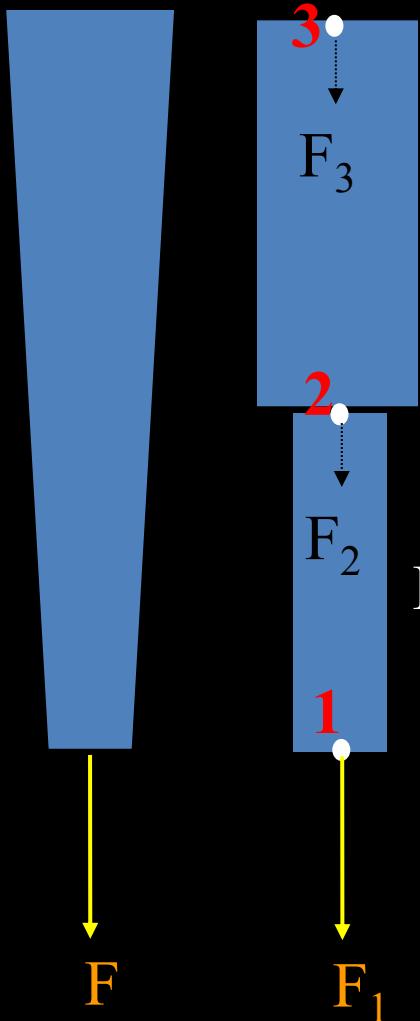
(1)

(1) + (2)

$$[ka] + [kb] = \frac{\mathbf{A}_1 \mathbf{E}}{I} \begin{pmatrix} 1 & -1 & 0 \\ -1 & 1 & 0 \\ 0 & 0 & 0 \end{pmatrix} + \frac{\mathbf{A}_2 \mathbf{E}}{I} \begin{pmatrix} 0 & 0 & 0 \\ 0 & 1 & -1 \\ 0 & -1 & 1 \end{pmatrix}$$

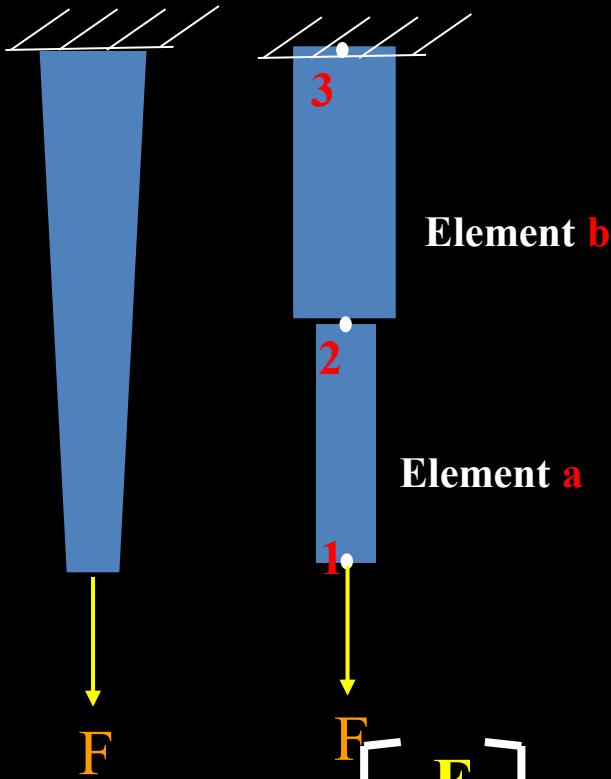
$$= \frac{\mathbf{E}}{I} \begin{pmatrix} A_1 & -A_1 & 0 \\ -A_1 & A_1 & 0 \\ 0 & 0 & 0 \end{pmatrix} + \frac{\mathbf{E}}{I} \begin{pmatrix} 0 & 0 & 0 \\ 0 & A_2 & -A_2 \\ 0 & -A_2 & A_2 \end{pmatrix}$$

$$= \frac{\mathbf{E}}{I} \begin{pmatrix} A_1 & -A_1 & 0 \\ -A_1 & A_1 + A_2 & -A_2 \\ 0 & -A_2 & A_2 \end{pmatrix}$$



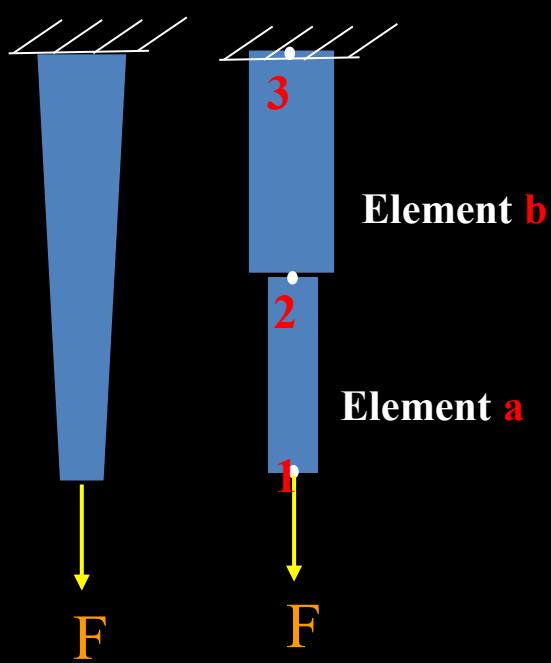
$$\left\{ \begin{array}{l} F_1 = k_1 d_1 \\ F_2 = k_2 d_2 \\ F_3 = k_3 d_3 \end{array} \right.$$

$$\left\{ \begin{array}{l} F_1 \\ F_2 \\ F_3 \end{array} \right\} = \left[\begin{array}{c} K \end{array} \right] \left\{ \begin{array}{l} d_1 \\ d_2 \\ d_3 \end{array} \right\}$$



Finite Element Method

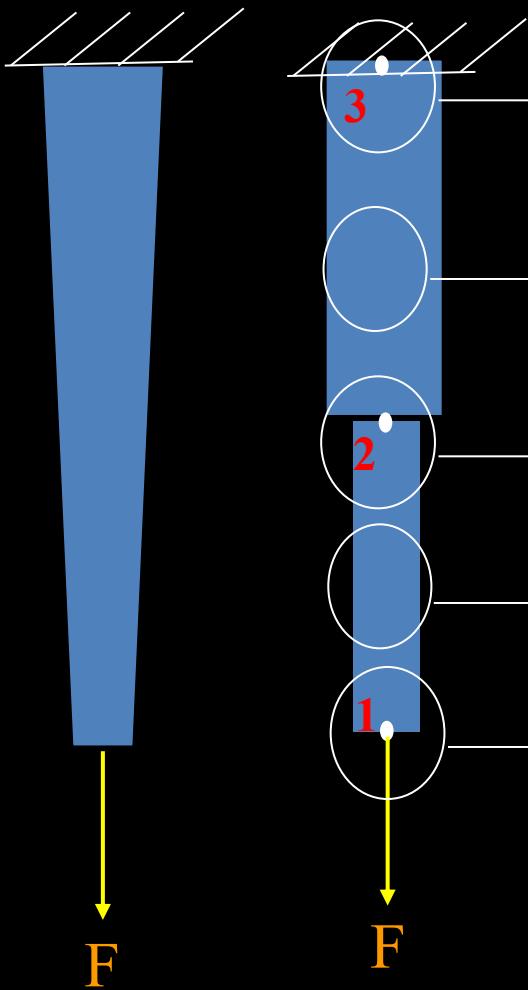
$$\begin{bmatrix} F_1 \\ F_2 \\ F_3 \end{bmatrix} = \frac{E}{l} \begin{bmatrix} A_1 & -A_1 & 0 \\ -A_1 & A_1 + A_2 & -A_2 \\ 0 & -A_2 & A_2 \end{bmatrix} \begin{bmatrix} d_1 \\ d_2 \\ d_3 \end{bmatrix}$$



$$\left\{ \begin{array}{l} F_1 = \frac{E}{I} (A_1 d_1 - A_1 d_2) \\ F_2 = \frac{E}{I} [-A_1 d_1 + (A_1 + A_2)d_2 - A_2 d_3] \\ F_3 = \frac{E}{I} (-A_2 d_2 - A_1 d_2) \end{array} \right.$$

Variants: $F_1, F_2, F_3, d_1, d_2, d_3$

$$\left\{ \begin{array}{l} F_1 = F \quad \text{----- external force is given} \\ F_2 = 0 \\ d_3 = 0 \quad \text{----- boundary condition is given} \end{array} \right.$$



$$\sigma_3 = F_3 / A_3$$

$$\varepsilon_3 = d_3 / L_3$$

$$\sigma_{2/3} = \frac{1}{2} (\sigma_3 + \sigma_2)$$

$$\varepsilon_{2/3} = \frac{1}{2} (\varepsilon_3 + \varepsilon_2)$$

$$\sigma_2 = F_2 / A_2$$

$$\varepsilon_2 = d_2 / L_2$$

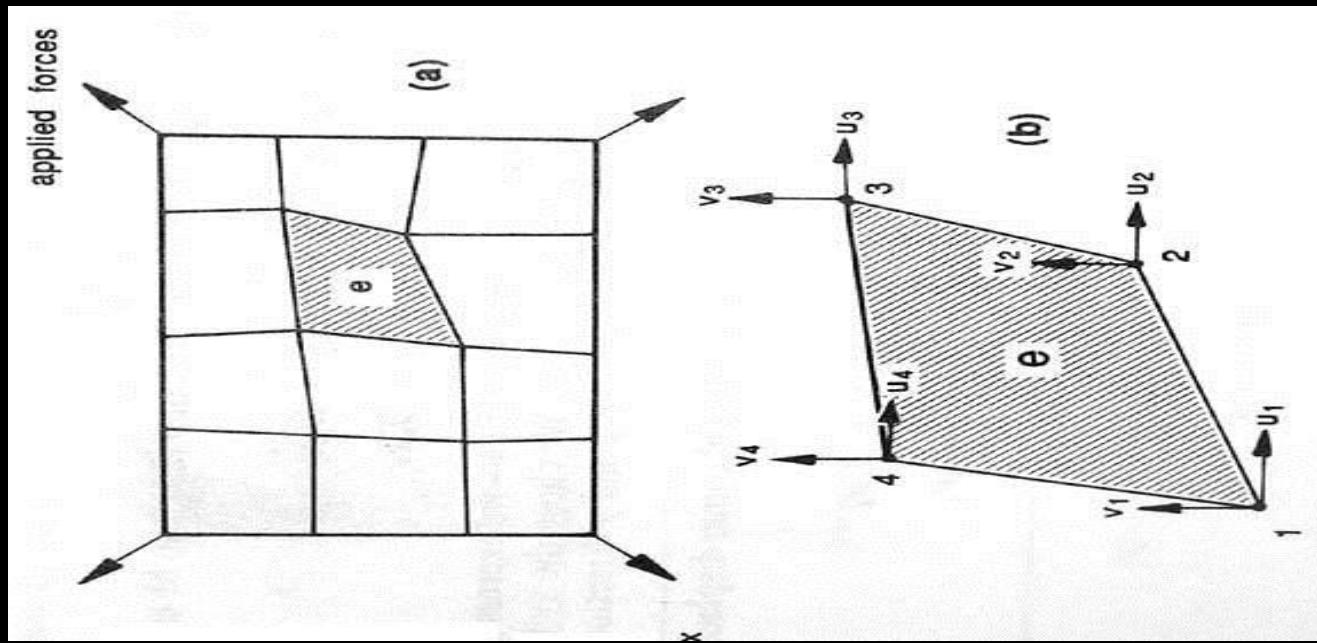
$$\sigma_{1/2} = \frac{1}{2} (\sigma_1 + \sigma_2)$$

$$\varepsilon_{1/2} = \frac{1}{2} (\varepsilon_1 + \varepsilon_2)$$

$$\sigma_1 = F_1 / A_1$$

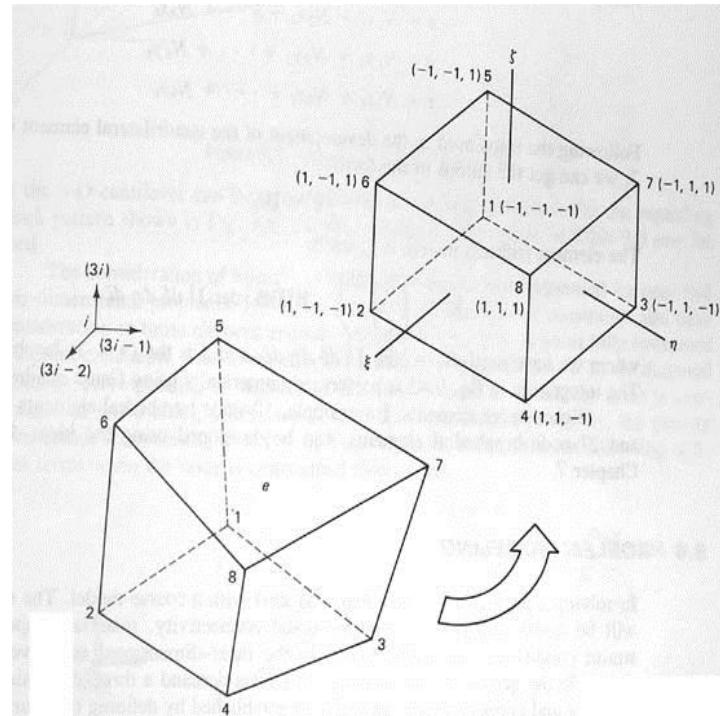
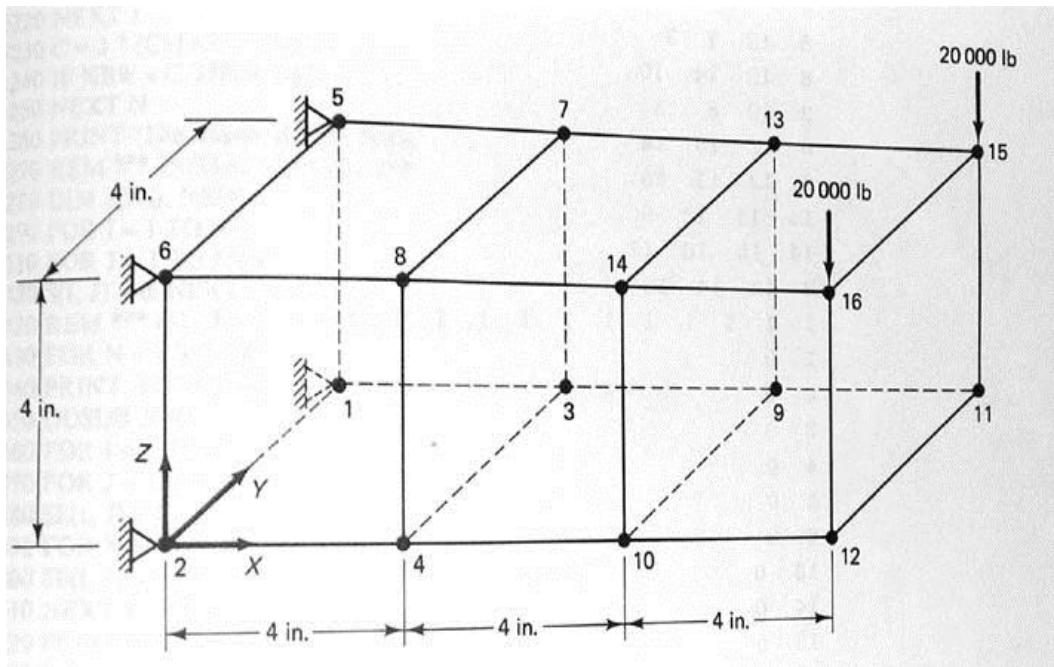
$$\varepsilon_1 = d_1 / L_1$$

Two-dimensional FEM



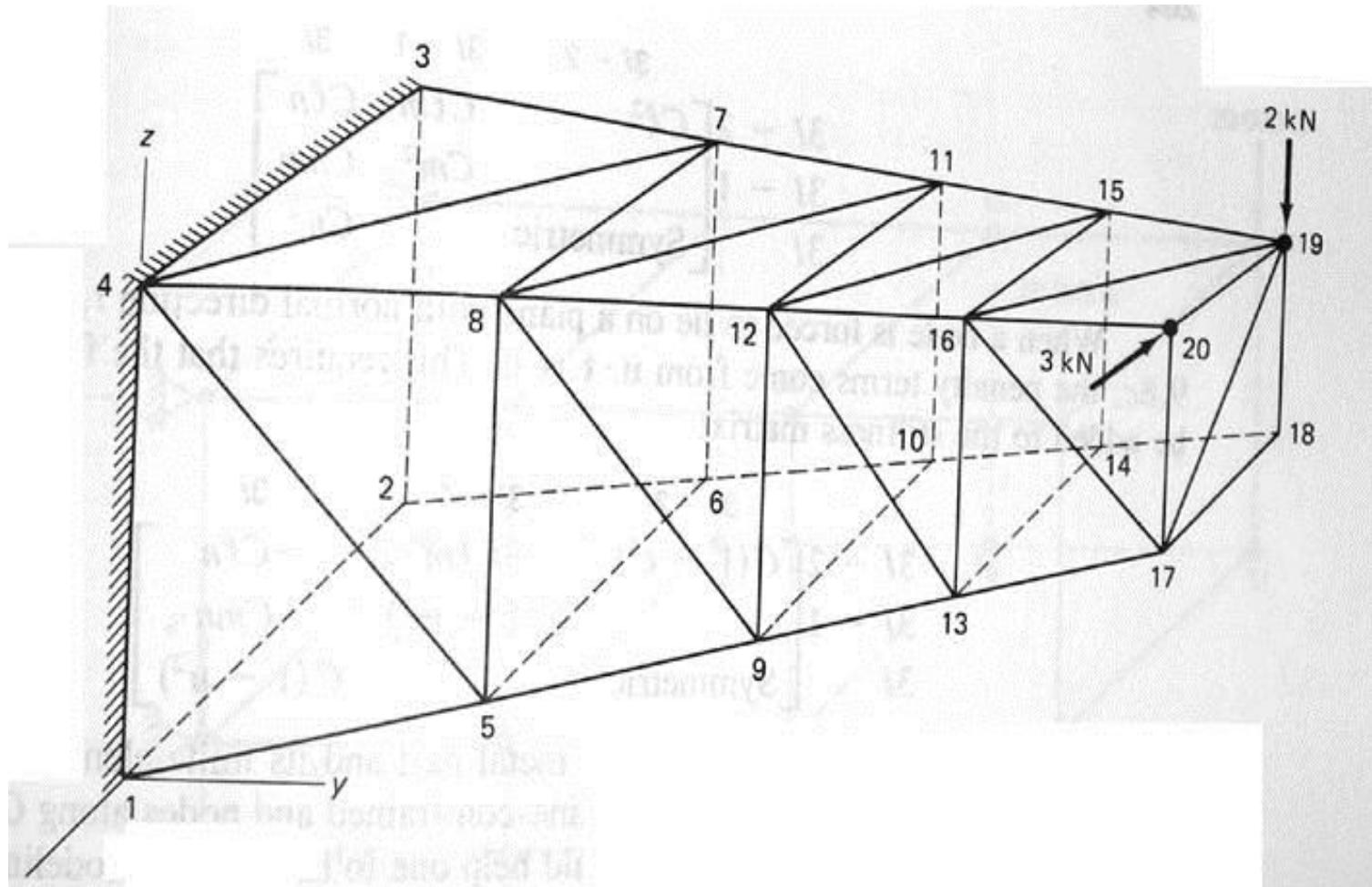
$$\begin{bmatrix} F_{x1} \\ F_{y1} \\ F_{x2} \\ F_{y2} \\ \vdots \\ \vdots \end{bmatrix} = \frac{AE}{l} \begin{bmatrix} 8 & X & 8 \end{bmatrix} \begin{bmatrix} d_{x1} \\ d_{y1} \\ d_{x2} \\ d_{y2} \\ \vdots \\ \vdots \end{bmatrix}$$

Three-dimensional FEM

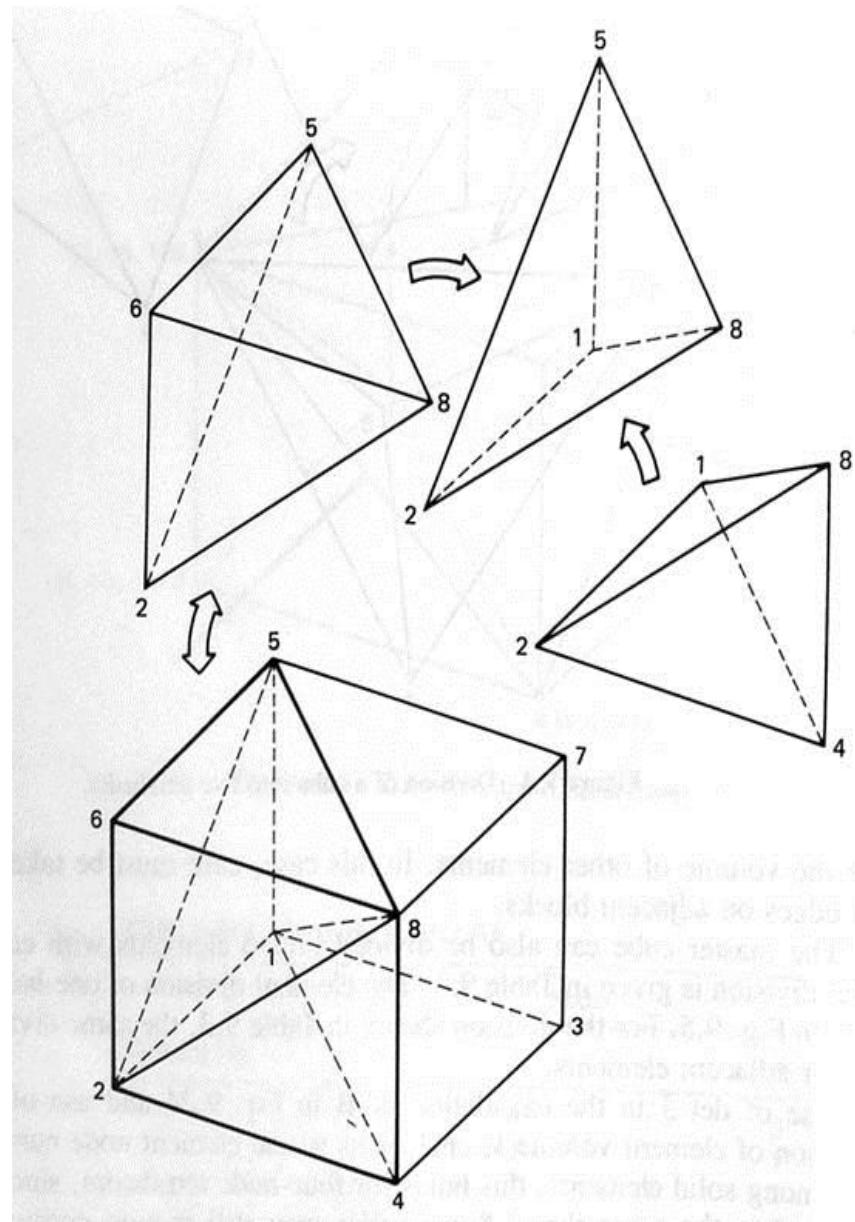
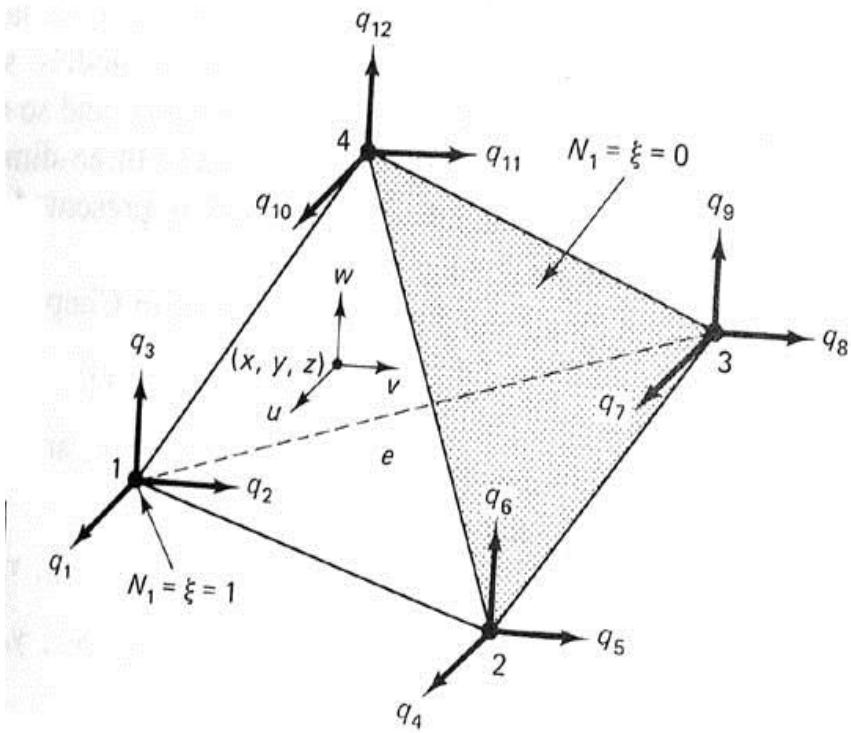


$$\begin{matrix}
 F_{x1} \\
 F_{y1} \\
 F_{z1} \\
 F_{x2} \\
 F_{y2} \\
 \cdot \\
 \cdot
 \end{matrix}
 = \frac{AE}{l} \left[\begin{matrix}
 & 24 \times 24 \\
 24 \times 24 &
 \end{matrix} \right] \begin{matrix}
 d_{x1} \\
 d_{y1} \\
 d_{z1} \\
 d_{x2} \\
 d_{y2} \\
 \cdot \\
 \cdot
 \end{matrix}$$

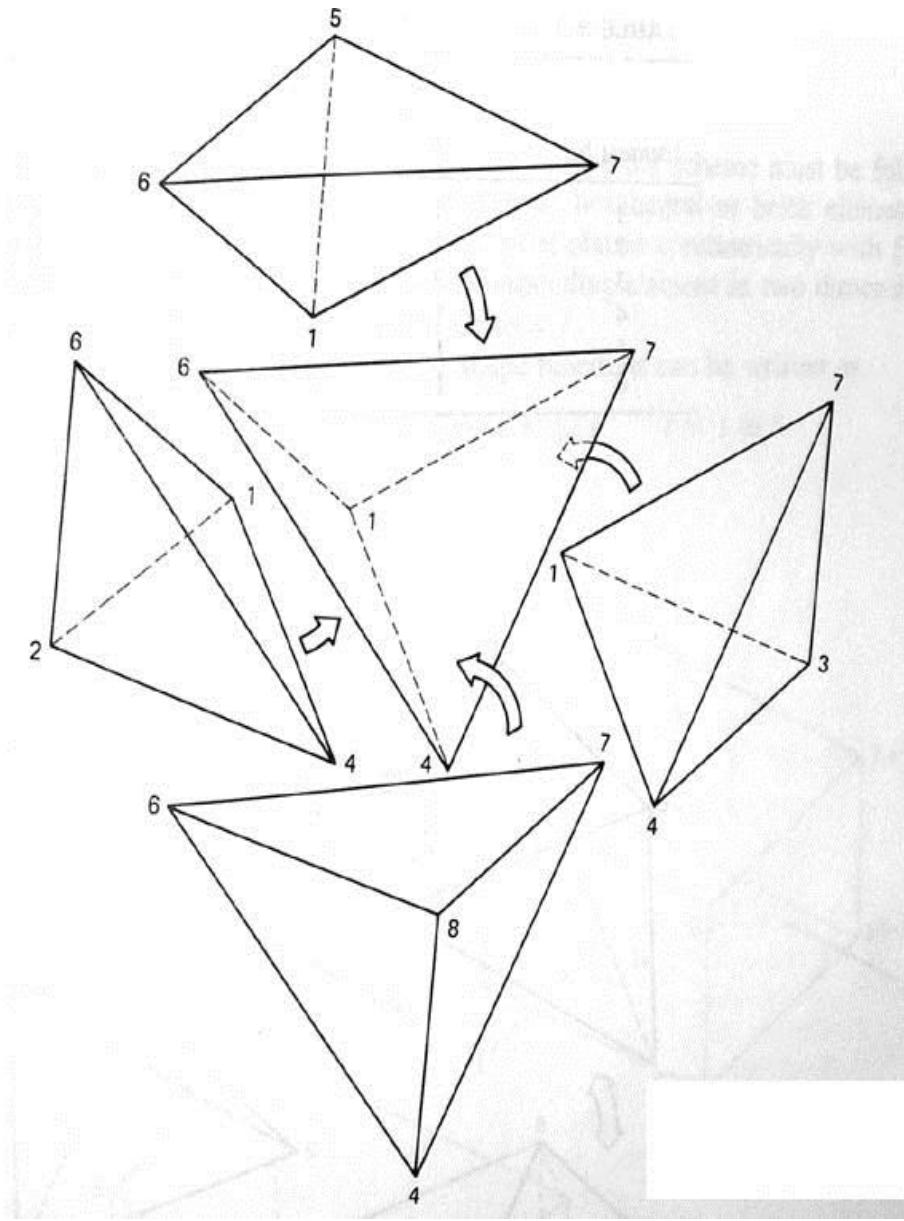
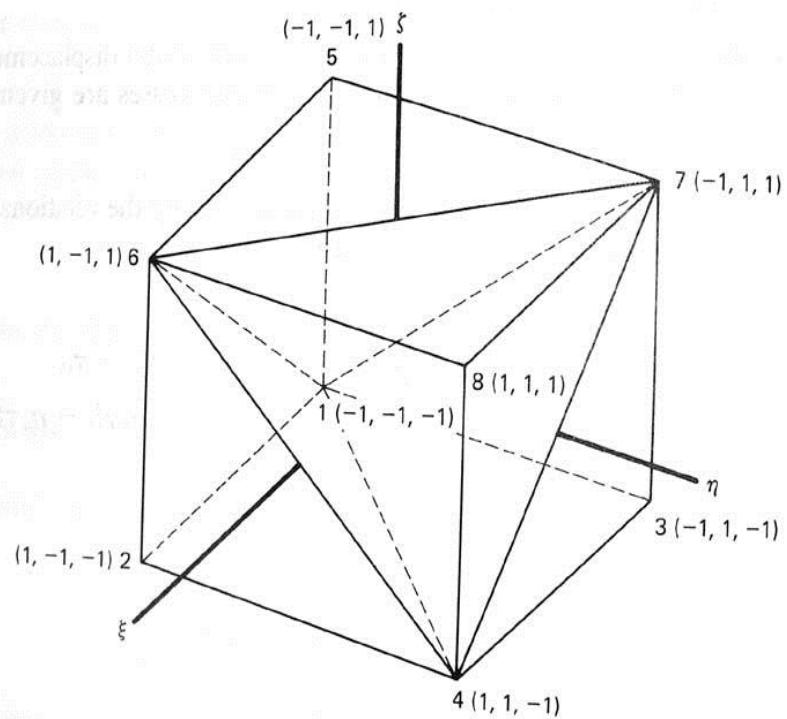
Three-dimensional irregular model



Division of a cube into six tetrahedra



Division of a cube into five tetrahedra



Elements used in FEM

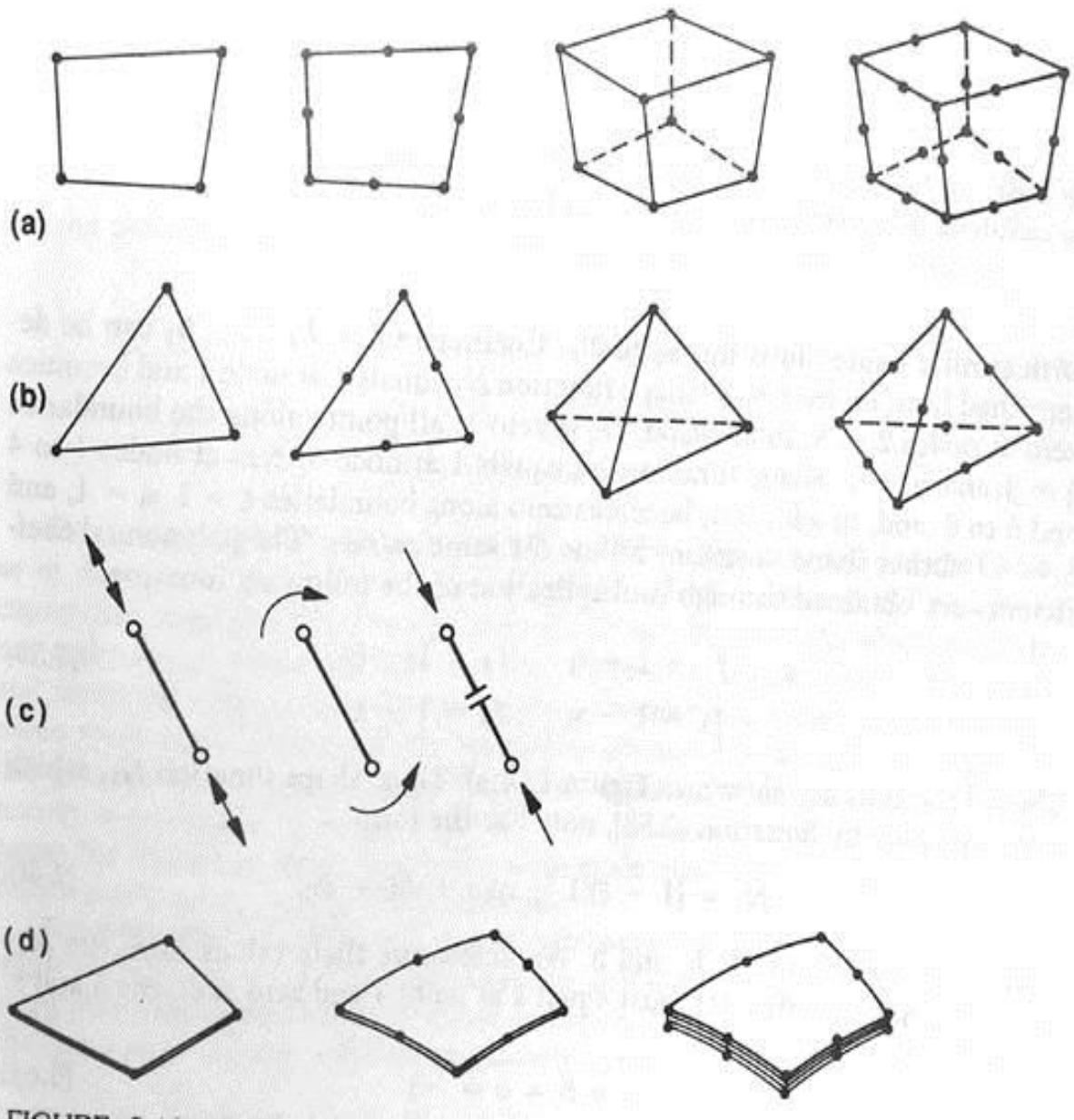


FIGURE -

- Convert CT image to solid model

- 01 Materialize Mimics 
- 02 Geomagics Design X 
- 03 Solidworks 
- 04 Ansys 

計畫簡述

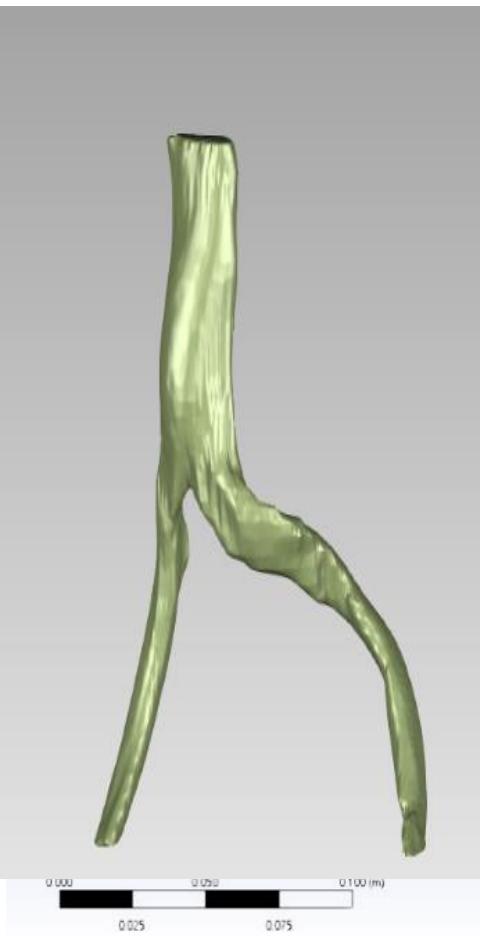
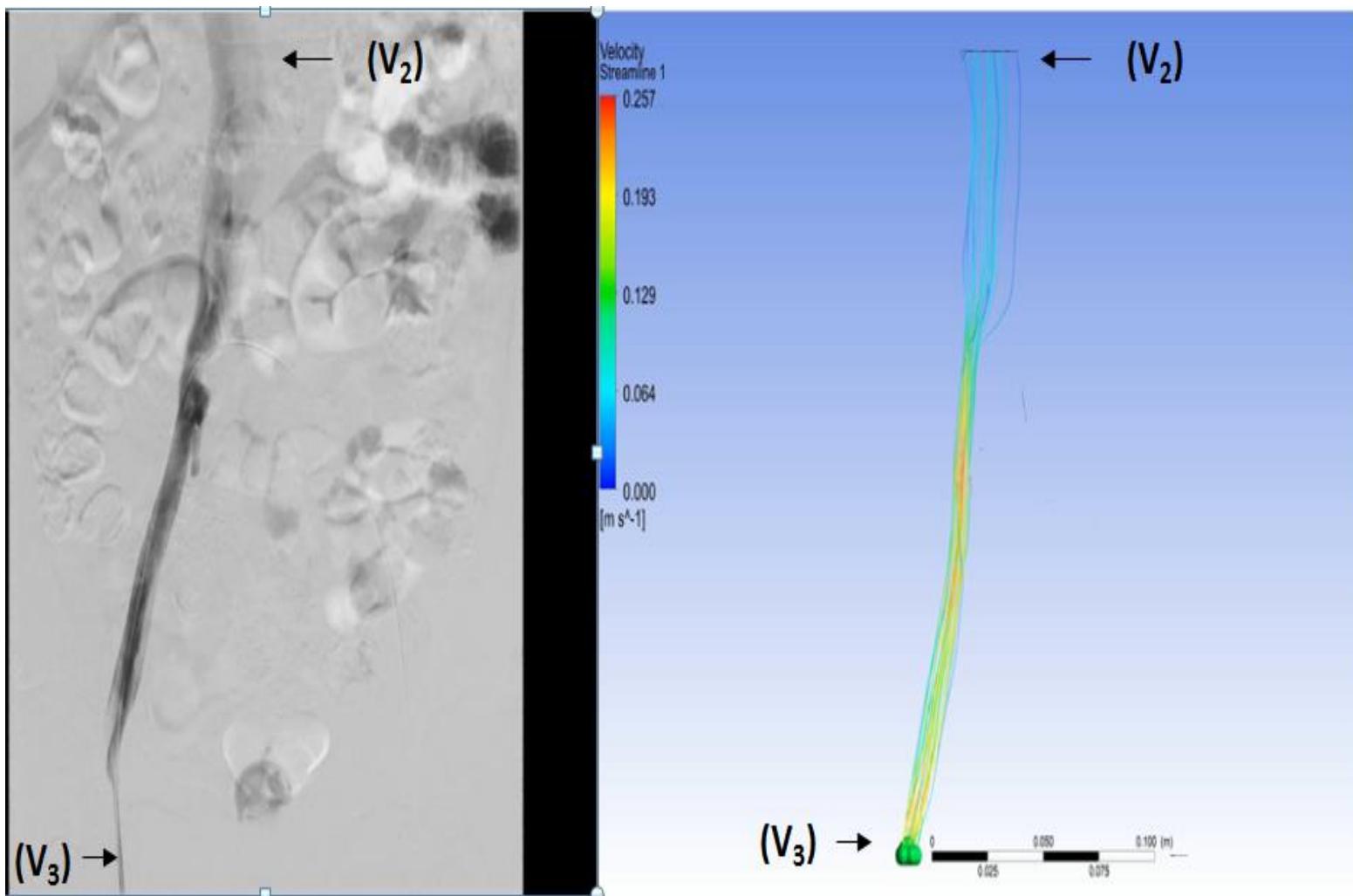
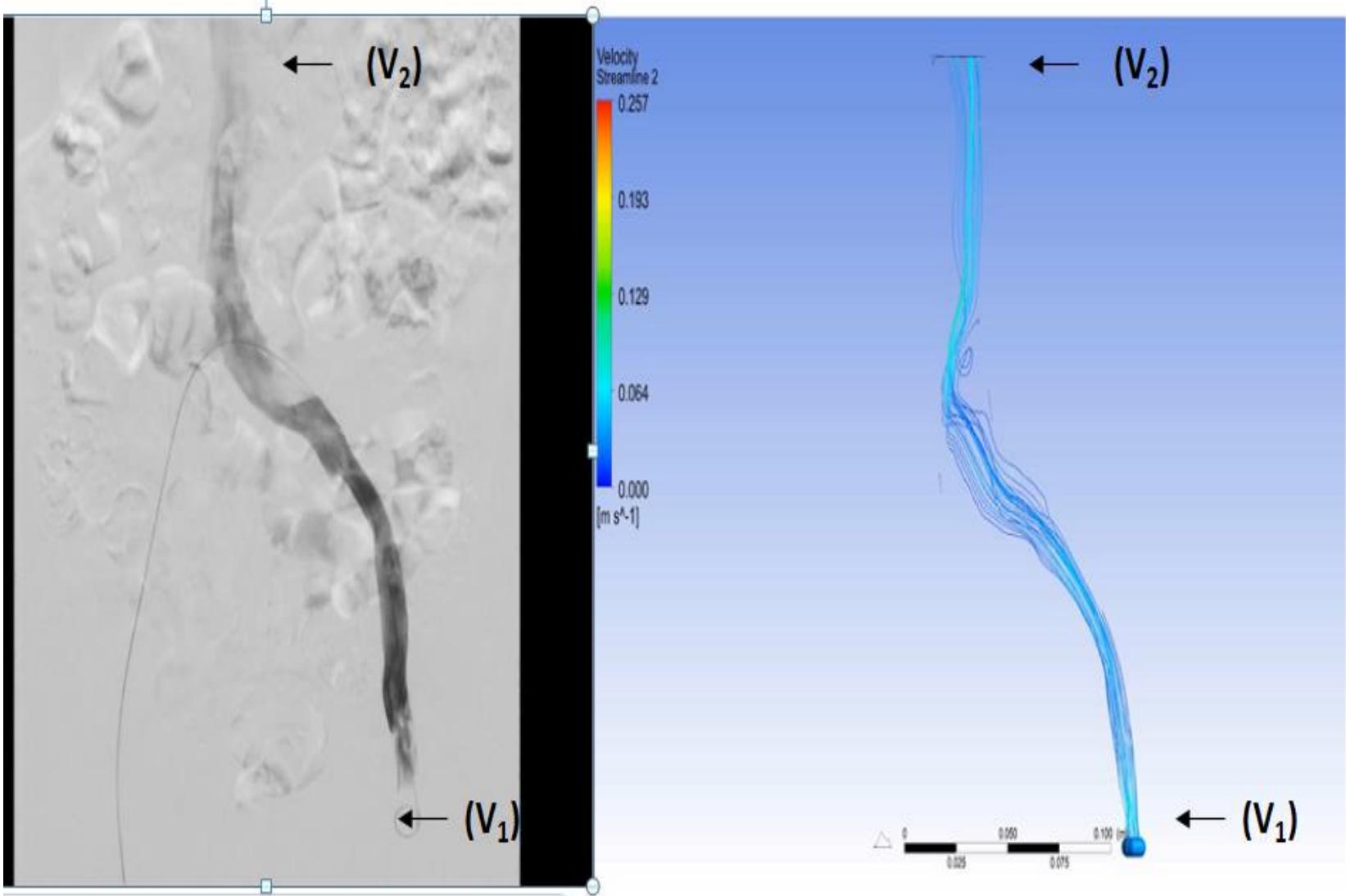


Fig. 1





血液是牛頓流?還是非牛頓流

牛頓流體Newtonian fluid指應力與應變率成正比的流體，黏滯係數為常數，例如水。

血液中有大量的水(density 1050 kg/m^3 , dynamic viscosity $0.003 \text{ kg/m}\cdot\text{s}$)，所以是牛頓流?

非牛頓流體 (Non-Newtonian fluid)，與牛頓流體相對，它的應力與速度梯度的關係不服從牛頓粘性定律，黏滯係數不為常數，也就是說其剪應力與剪應變呈非線性關係。如：高分子聚合物溶液等

血液中有大量的血球所以是非牛頓流?

大血管傾向於牛頓流體

小血管或為循環系統傾向於非牛頓流

層流模型？還是擾流模型？

層流模型：適合動脈分析，或血管壁議題研究。

湍流模型：適合血管中央區的速度場或壓力梯度研究。

納維-斯托克斯方程式 (Navier-Stokes方程)：用于描述流體運動的方程，可以看作是流體運動的牛頓第二定律。對於可壓縮的牛頓流體

$$\underbrace{\rho \left(\frac{\partial \mathbf{u}}{\partial t} + \mathbf{u} \cdot \nabla \mathbf{u} \right)}_1 = \underbrace{-\nabla p}_2 + \underbrace{\nabla \cdot (\mu(\nabla \mathbf{u} + (\nabla \mathbf{u})^T)) - \frac{2}{3}\mu(\nabla \cdot \mathbf{u})\mathbf{I}}_3 + \underbrace{\mathbf{F}}_4$$

- (1) 慣性力
- (2) 壓力
- (3) 黏性力
- (4) 作用在流體上的外力

高雷諾數湍流模型

- 在雷諾數非常高的工程應用中，慣性力遠大於黏性力。
- 需要使用足夠精細的網格，才能求解最小渦流的大小。使用 NS 方程計算此類問題，往往會超出當今大多數電腦和超級電腦的計算能力。
- 利用納維-斯托克斯方程的雷諾平均納維-斯托克斯 (RANS) 公式，對速度和壓力場取時間平均值，以降低此類模擬對計算能力的要求。

$$\underbrace{\rho(\mathbf{U} \cdot \nabla \mathbf{U}) + \nabla \cdot (\mu_T(\nabla \mathbf{U} + (\nabla \mathbf{U})^T) - \frac{2}{3}\mu_T(\nabla \cdot \mathbf{U})\mathbf{I})}_{1} = \underbrace{-\nabla P}_{2} + \underbrace{\nabla \cdot (\mu(\nabla \mathbf{U} + (\nabla \mathbf{U})^T) - \frac{2}{3}\mu(\nabla \cdot \mathbf{U})\mathbf{I})}_{3} + \underbrace{\mathbf{F}}_{4}$$

一方程：

Spalart-Allmaras模型

兩方程：

k- ω 模型 (適用非牛頓流血管分析)

k- ϵ 模型 (適用牛頓流血管分析): 具有較好的穩定性，能有效節省計算資源，

雙方程式湍流模型

標準 $k-\varepsilon$ 模型是針對湍流發展非常充分的湍流流動來建立的，因此，它是一種針對高雷諾數湍流的計算模型。當雷諾數較低時，不適宜直接採用該模型

$$\frac{\partial(\rho K)}{\partial t} + \frac{\partial(\rho \bar{u}_j K)}{\partial x_j} = \frac{\partial}{\partial x_j} \left[(\mu + \frac{\mu_t}{Pr_K}) \frac{\partial K}{\partial x_j} \right] + G_K - \rho \varepsilon$$

$$\frac{\partial \rho \varepsilon}{\partial t} + \frac{\partial(\rho \bar{u}_j \varepsilon)}{\partial x_j} = \frac{\partial}{\partial x_j} \left[(\mu + \frac{\mu_t}{Pr_\varepsilon}) \frac{\partial \varepsilon}{\partial x_j} \right] + C_{\varepsilon 1} \frac{\varepsilon}{K} G_K - C_{\varepsilon 2} \rho \frac{\varepsilon^2}{K}$$

K : 湍流動能

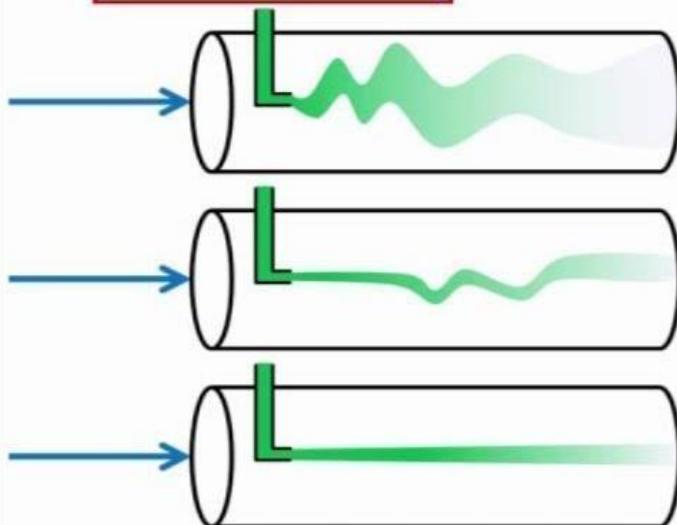
ε : 湍流動能耗散率

$k-\varepsilon$ 模型的缺點是對逆壓梯度和邊界層分離不敏感 (不在本研究之議題內)

流體狀態

Turbulent Flow, Transition Flow & Laminar Flow

$$Re = \frac{\rho V_{\text{avg}} D}{\mu}$$



$Re > 4000$

turbulent (unpredictable, rapid mixing)

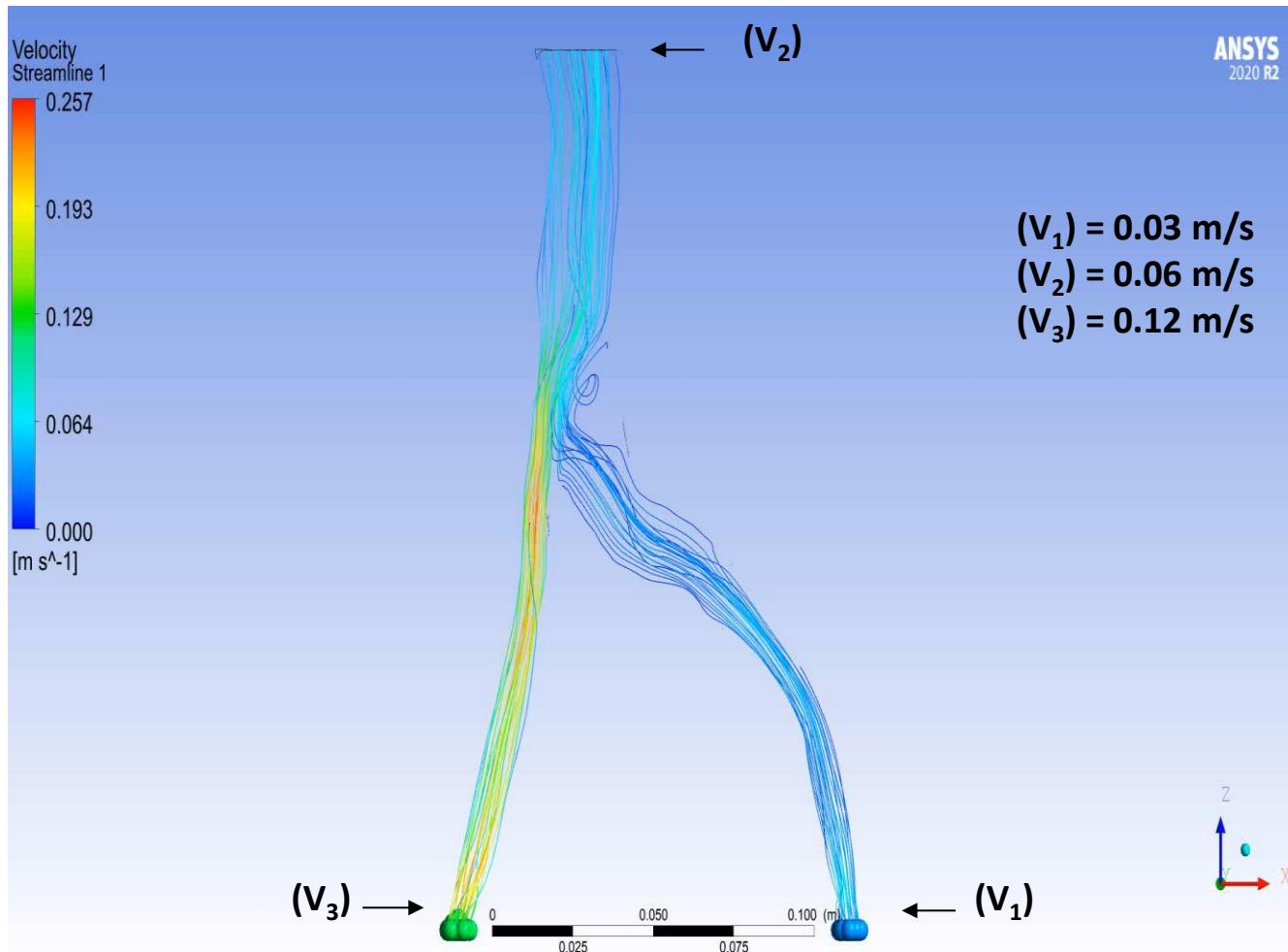
$2300 < Re < 4000$

transitional (turbulent outbursts)

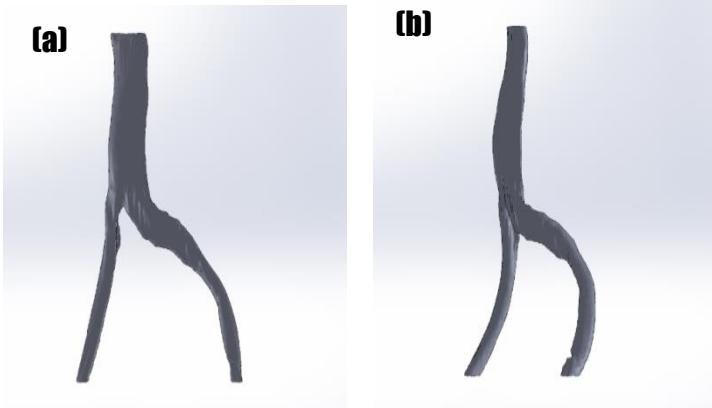
$Re < 2300$

laminar (predictable, slow mixing)

Comparison of real blood vessel angiography and simulation



Real model

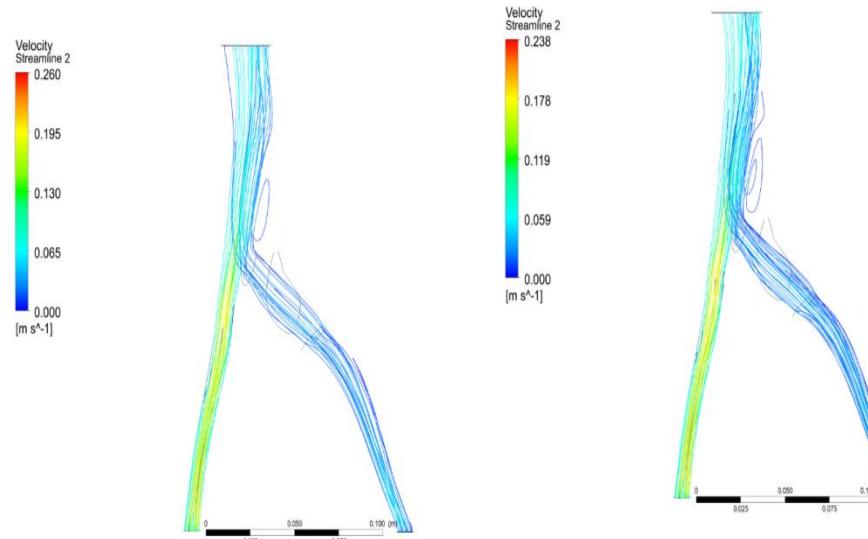
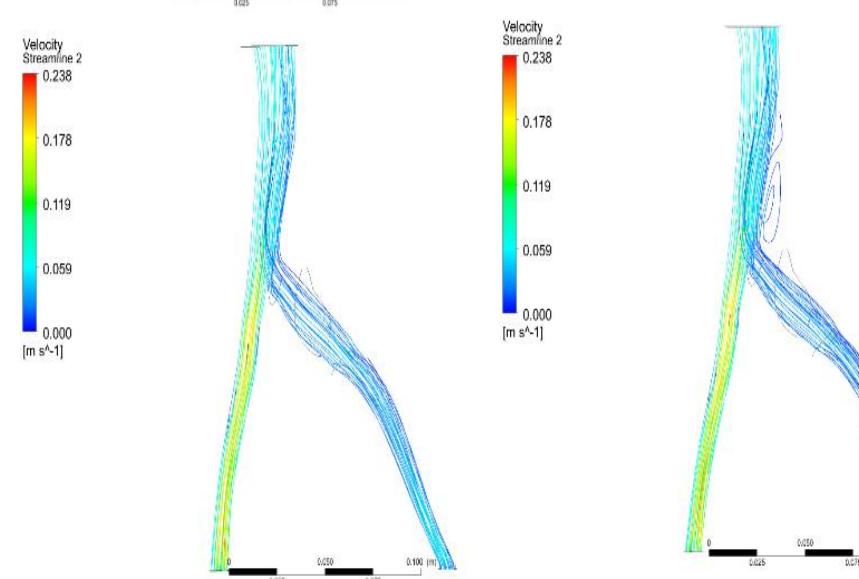


Simulation



Fig. 3

Patient model

Reversed
compressed model

VR = 2.0

VR = 2.5

Fig. 5

0.11m/s

Different angles of the iliac vein

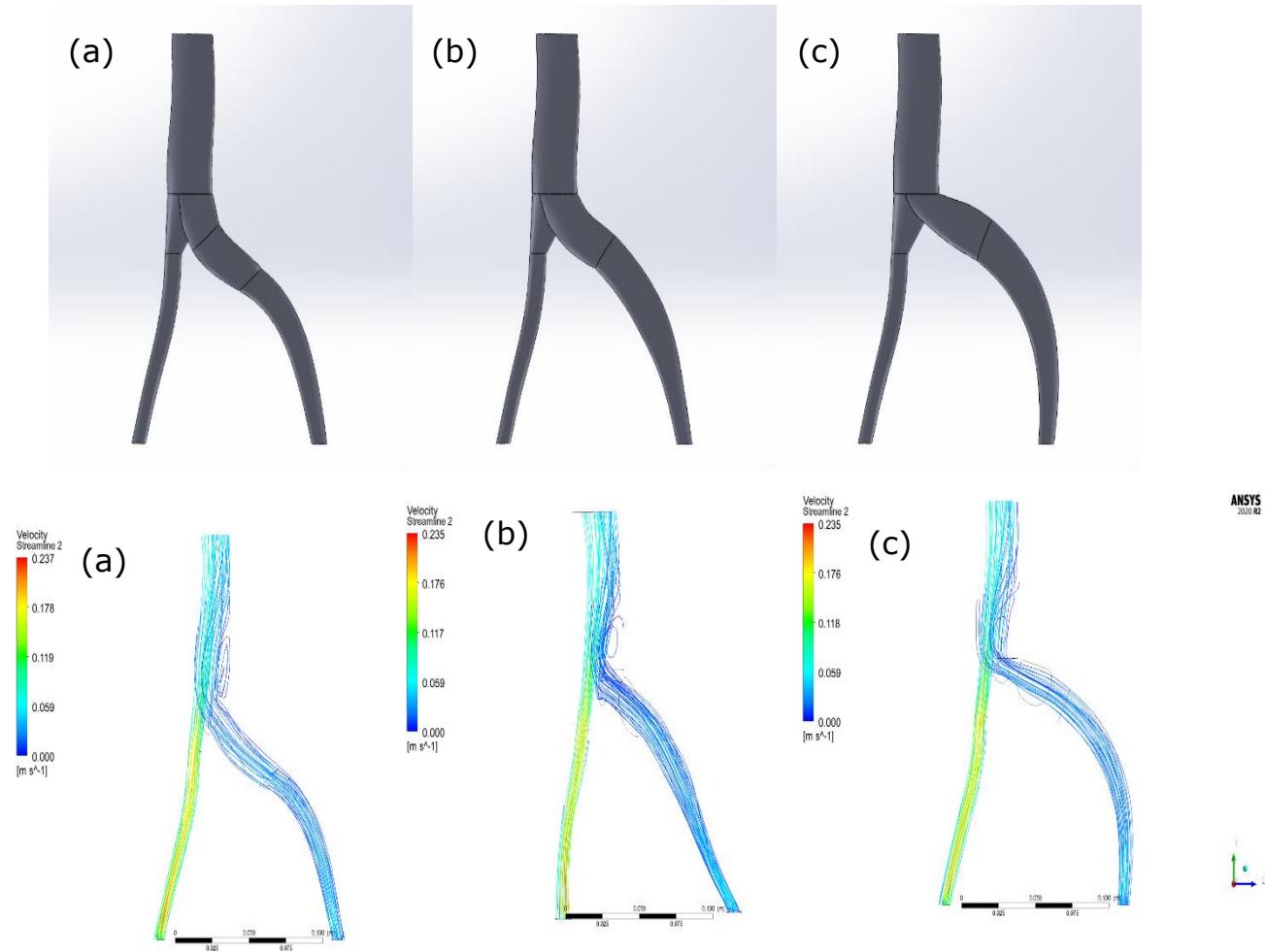
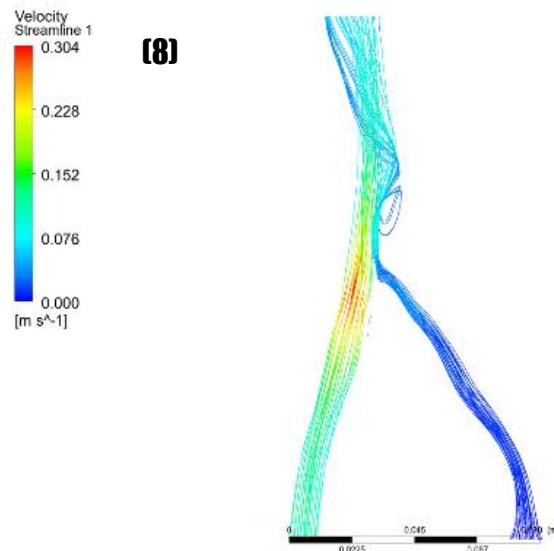


Figure 9. Different angles of the iliac vein.

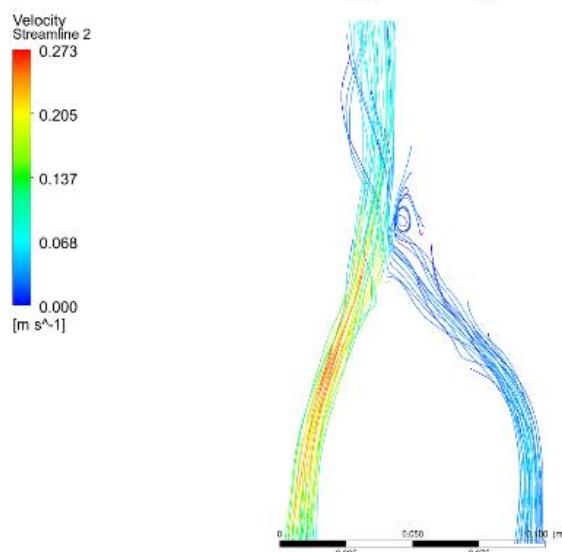
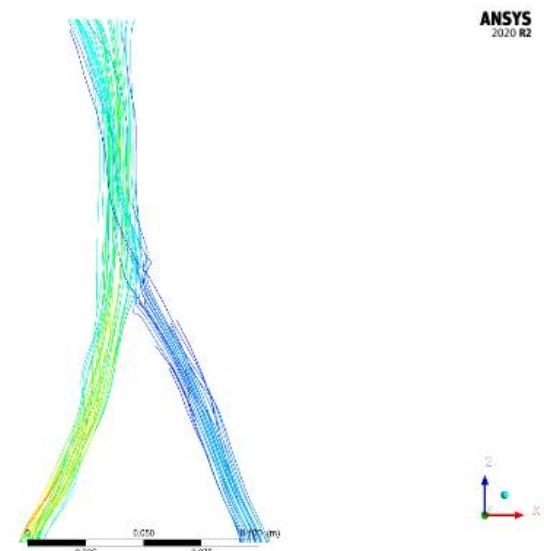
- (a) The patient's original vascular angle (51 ~ 70 degrees).
- (b) 71 ~ 90 degrees.
- (c) 91 ~ 100 degrees
- (d) >100 degrees.

具體成果-角度小於50度

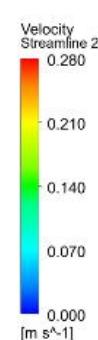


ANSYS
2020 R2

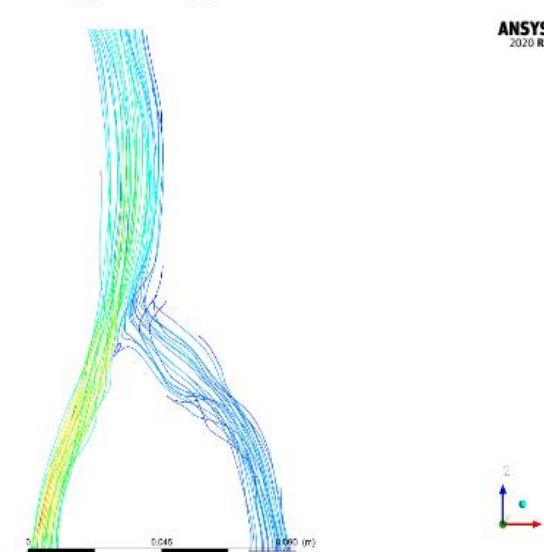
(9)



ANSYS
2020 R2

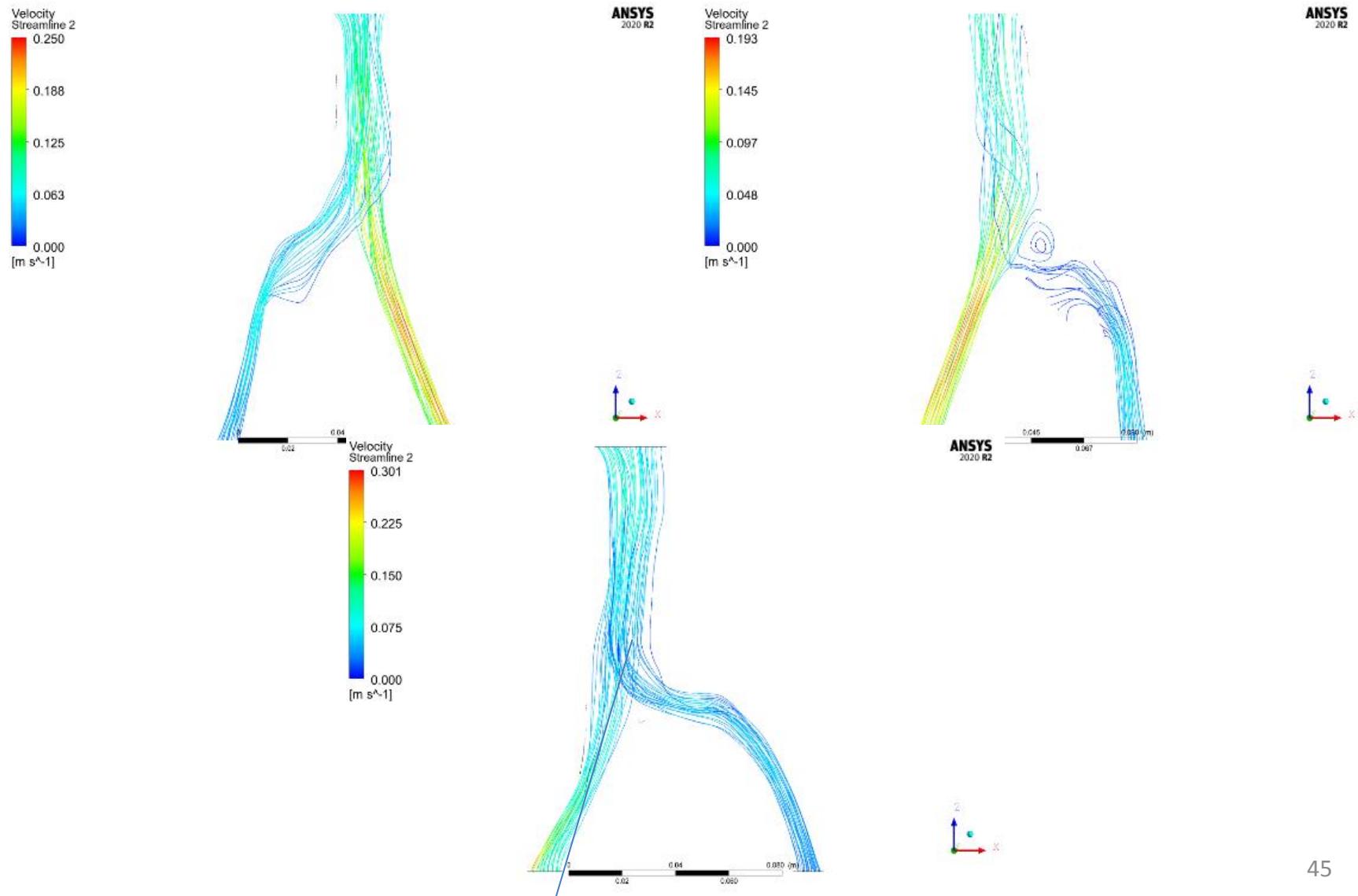


ANSYS
2020 R2

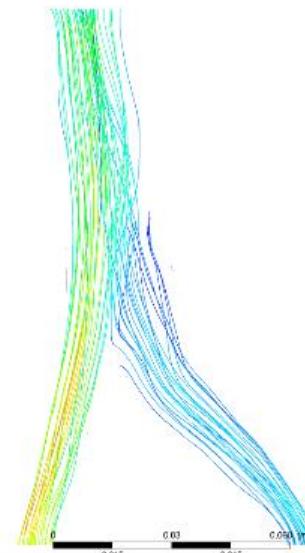
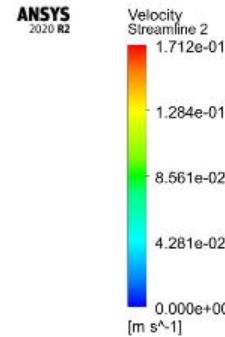
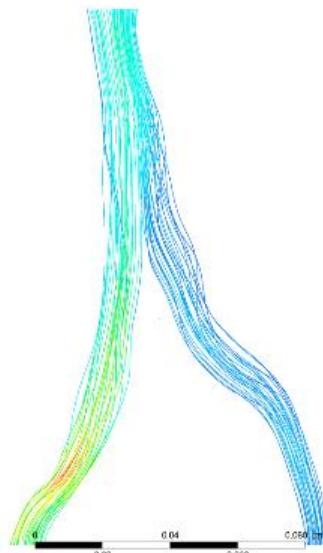
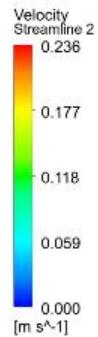


ANSYS
2020 R2

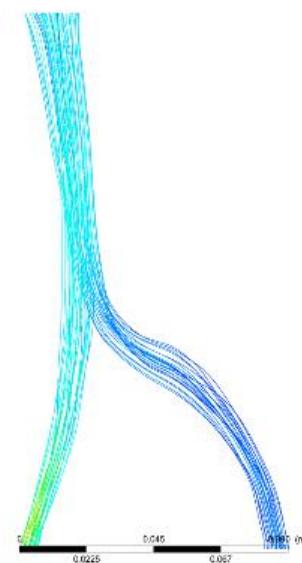
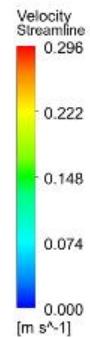
具體成果-角度小於50度



具體成果-角度約55度



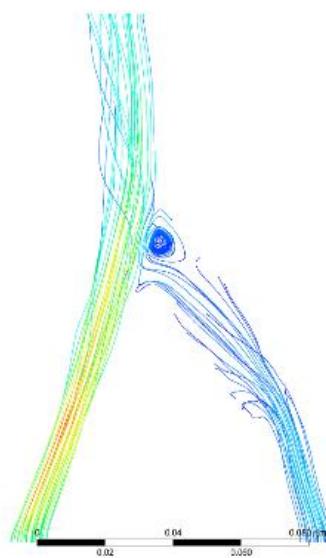
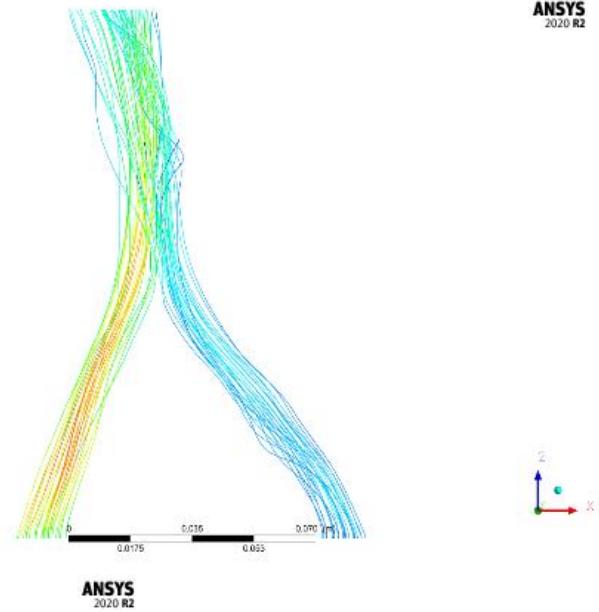
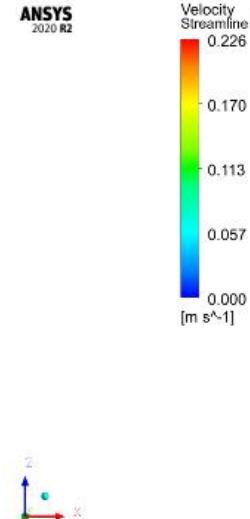
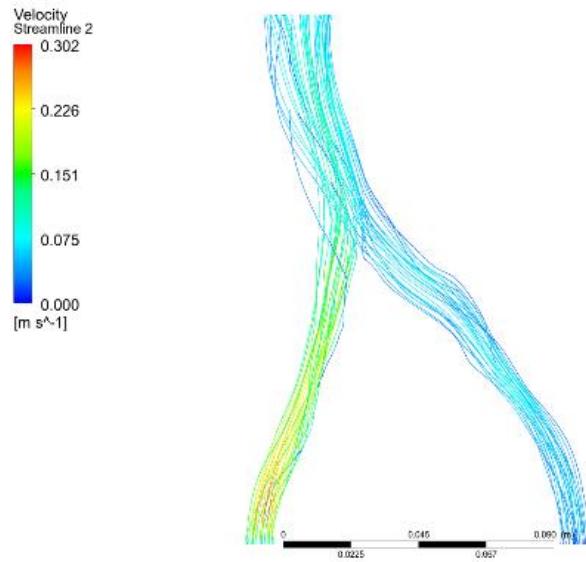
ANSYS
2020 R2



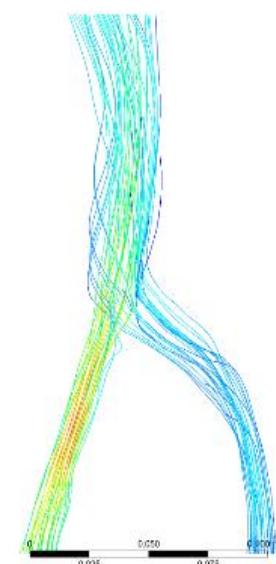
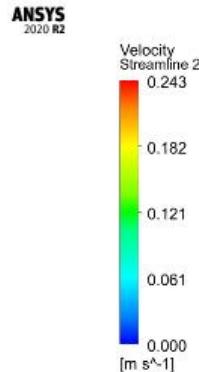
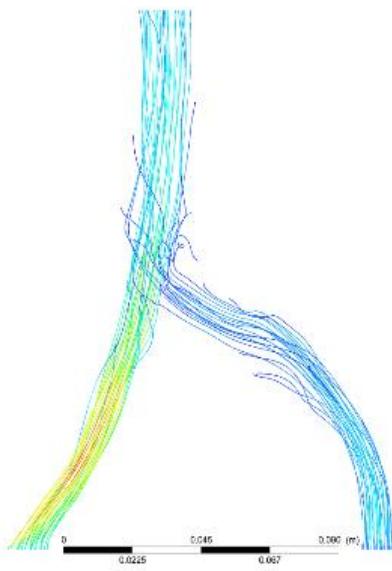
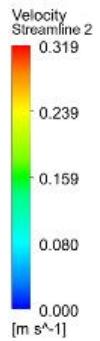
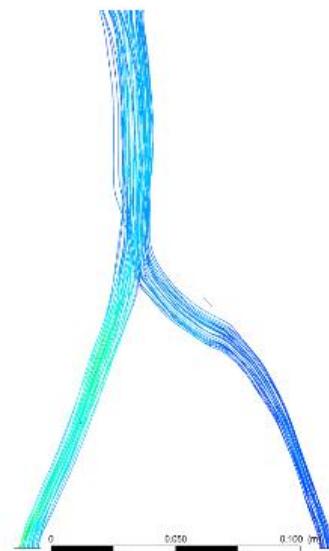
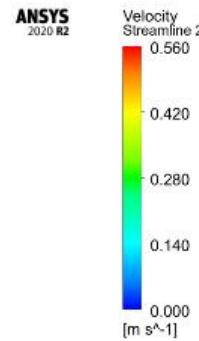
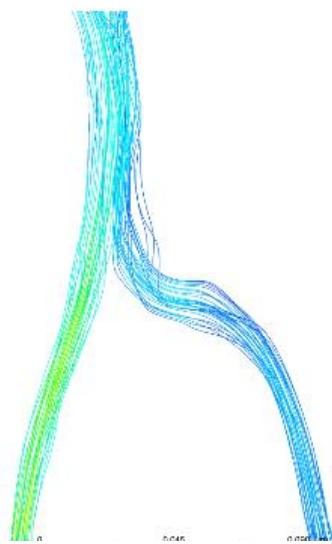
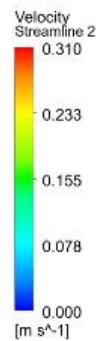
ANSYS
2020 R2



具體成果-角度約55度



具體成果-角度約65度



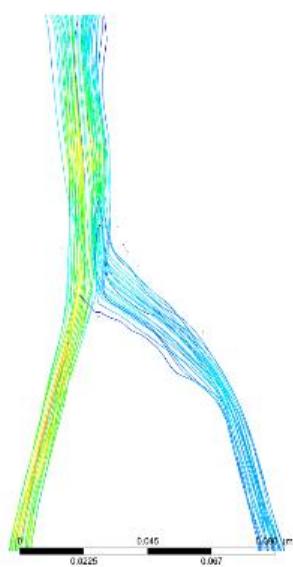
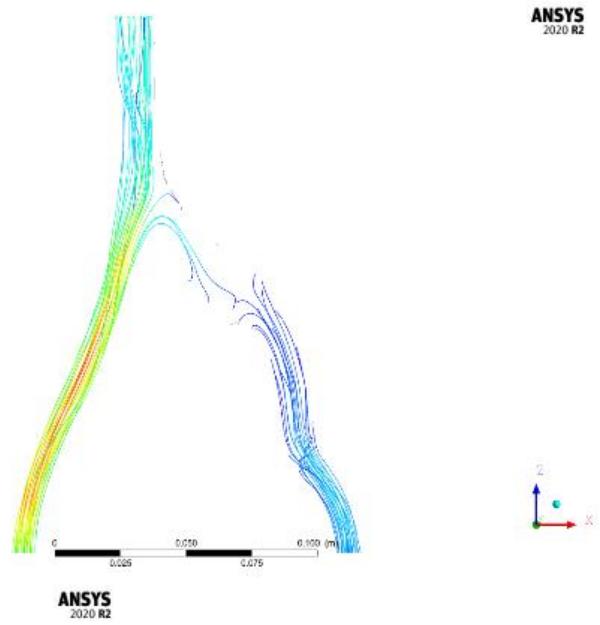
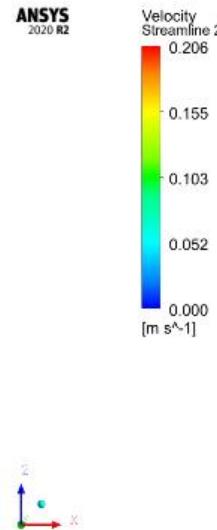
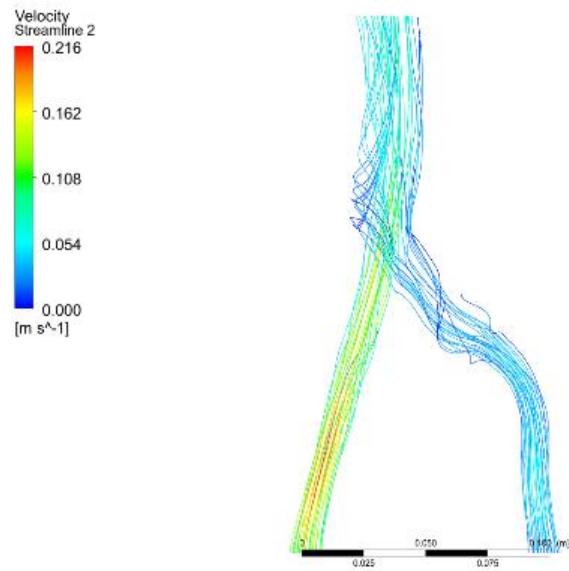
ANSYS
2020 R2



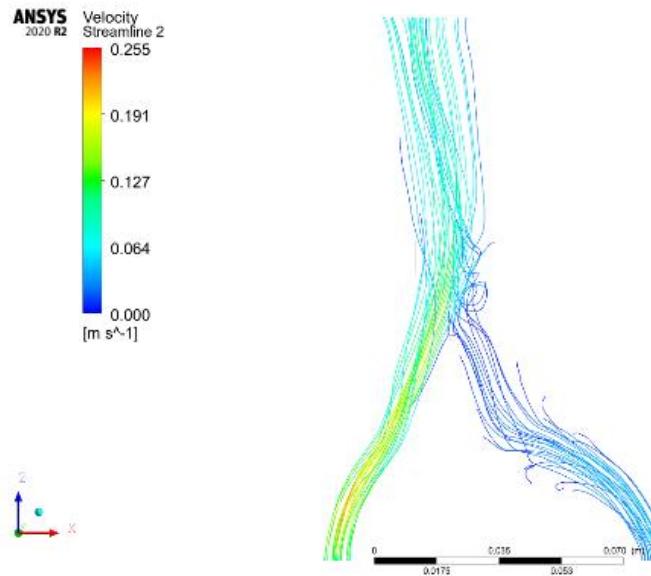
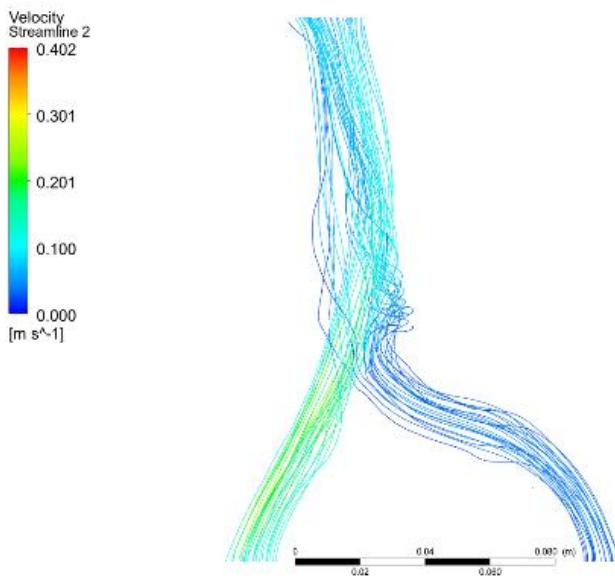
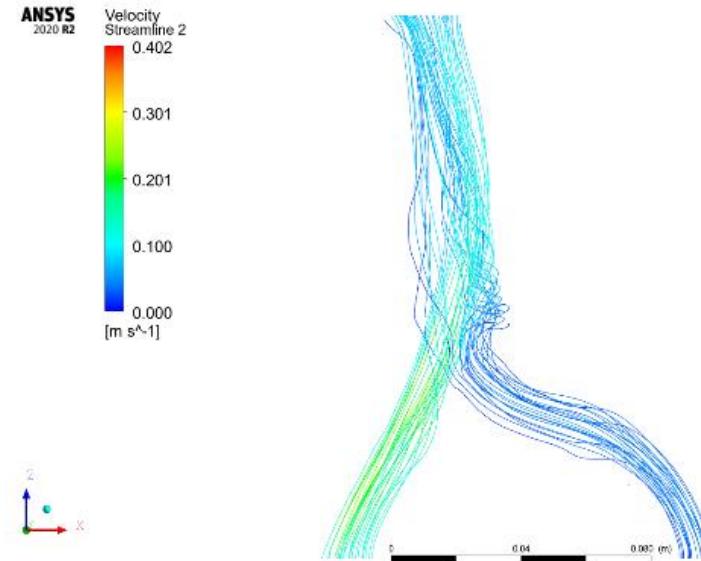
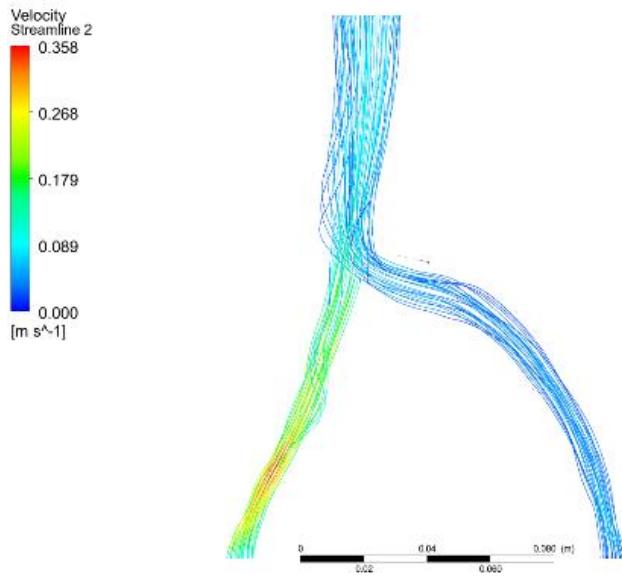
ANSYS
2020 R2



具體成果-角度約65度



具體成果-角度約75度



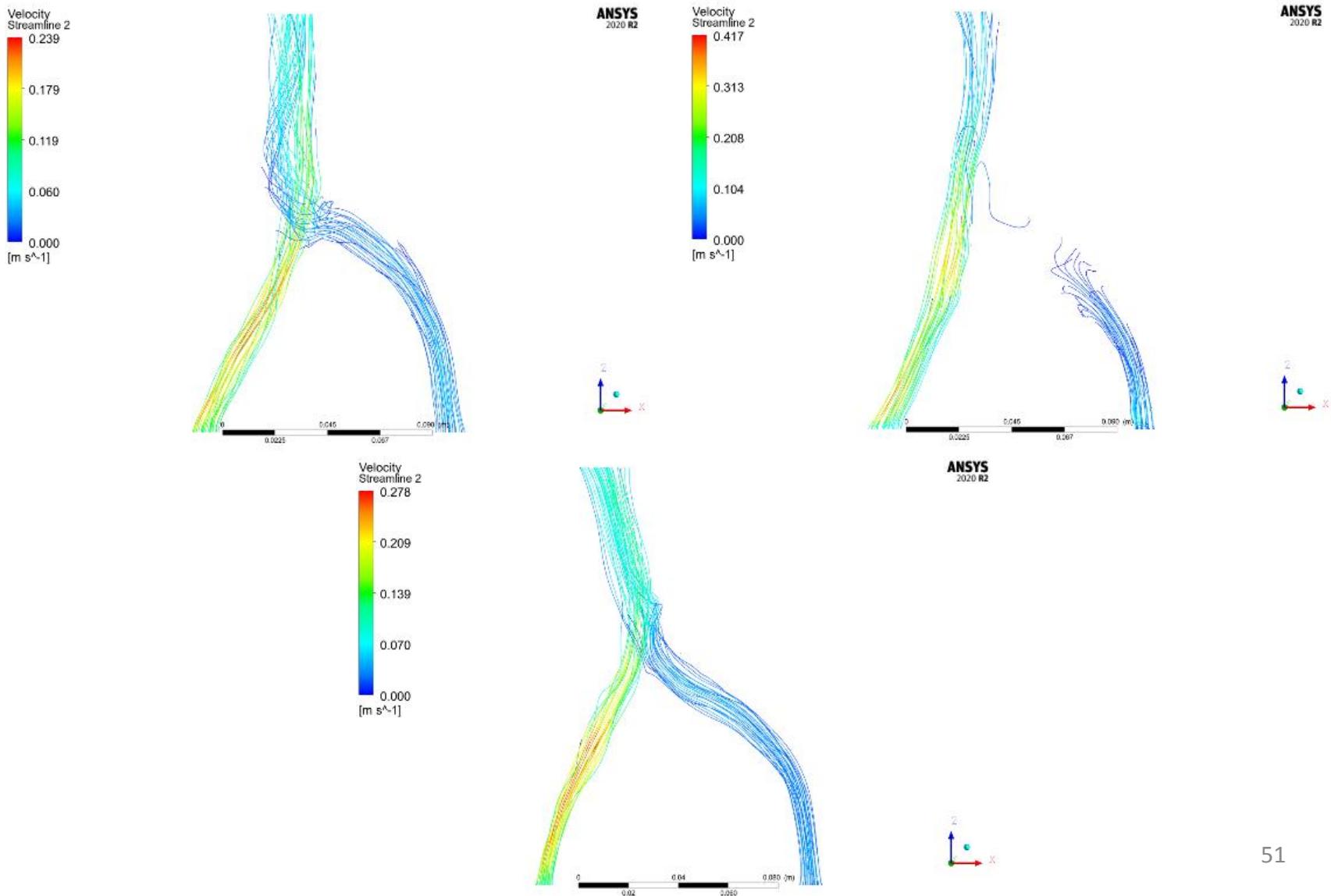
ANSYS
2020 R2



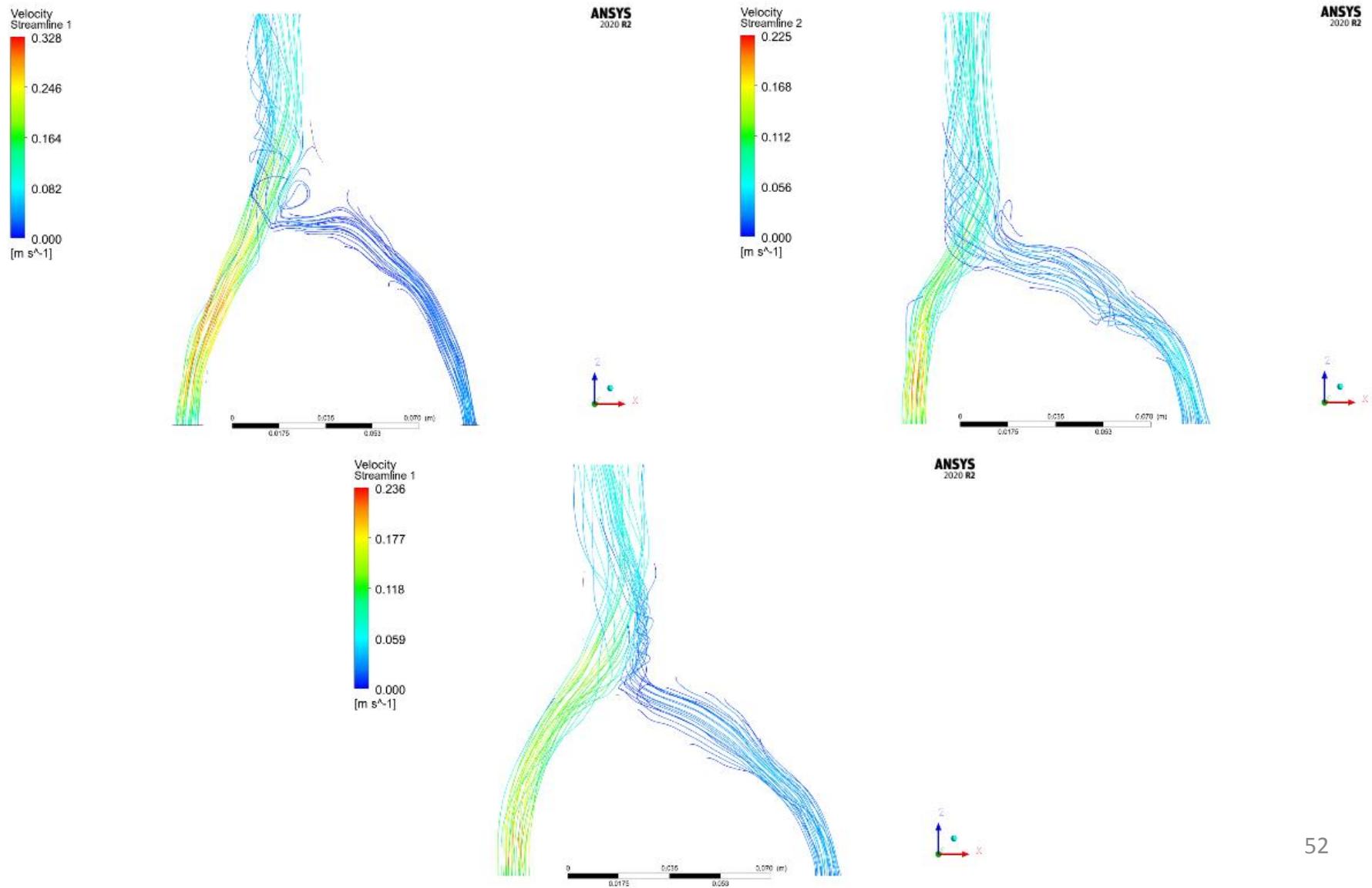
ANSYS
2020 R2



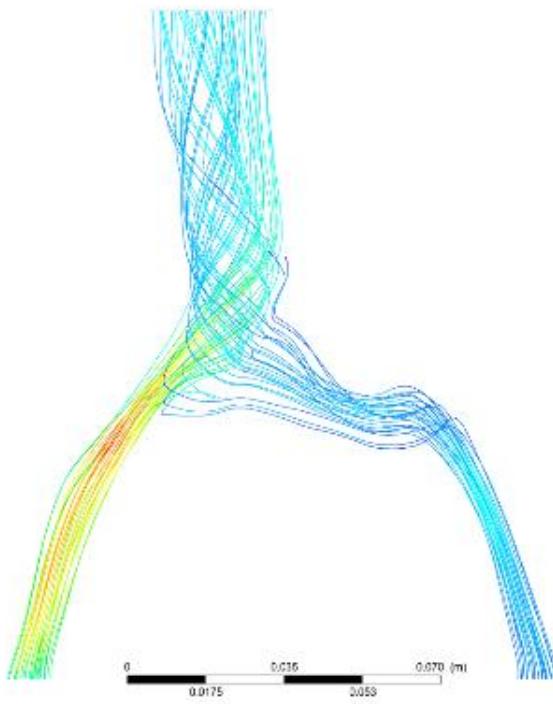
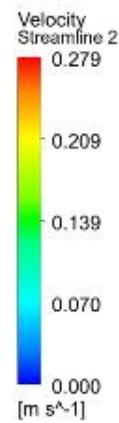
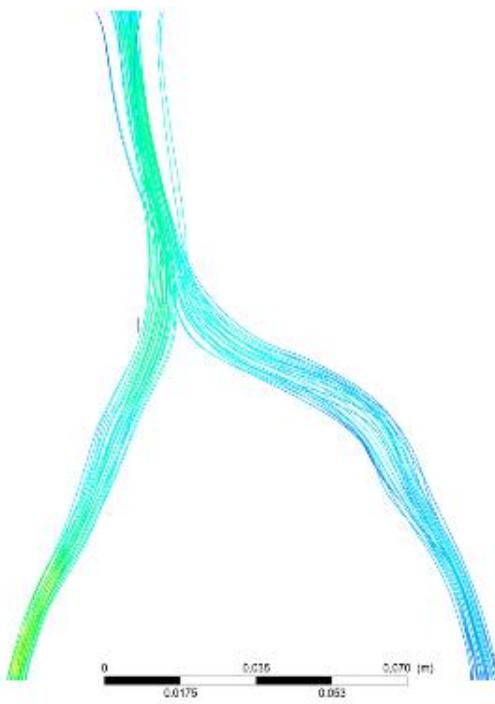
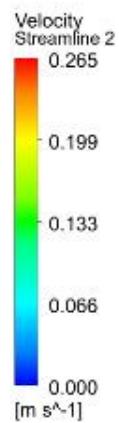
具體成果-角度約75度



具體成果-角度約90度



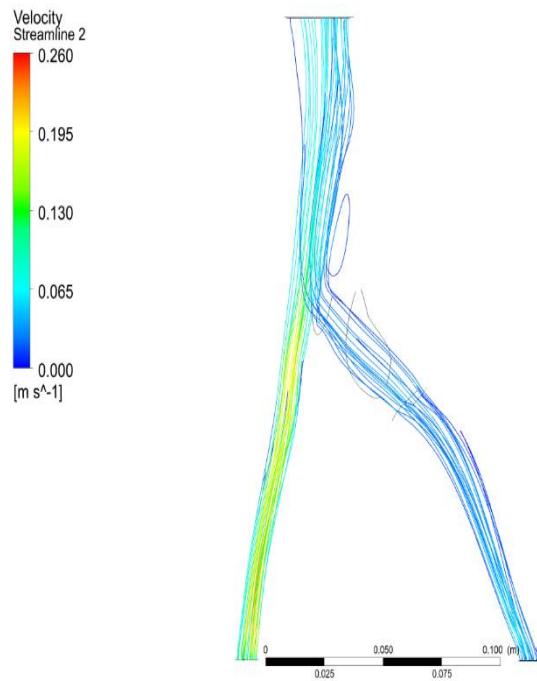
具體成果-角度約90度



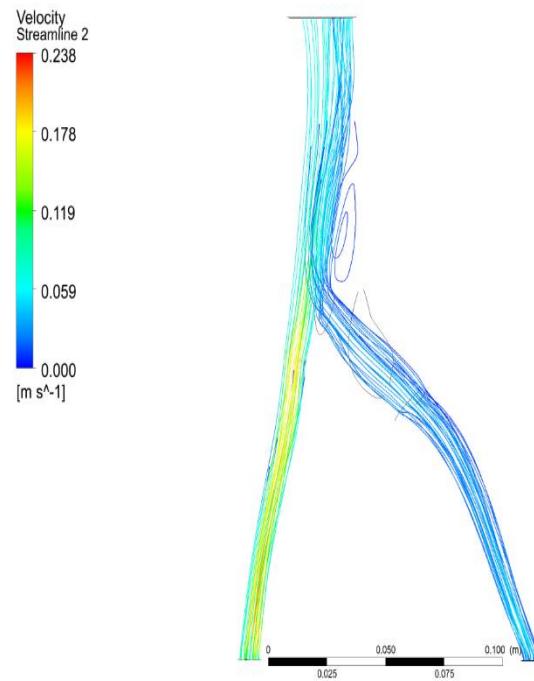
ANSYS
2020 R2



Compare with clinical data, verify model input conditions and the credibility of simulation methods



$V_2 : V_1 = 2:1, V_3 : V_1 = 4:1$
 $V_1 = 0.03.$



$V_2 : V_1 = 2.5:1, V_3 : V_1 = 4.58:1$
 $V_1 = 0.024.$

ANSYS
2020 R2



Compare with clinical data, verify model input conditions and the credibility of simulation methods

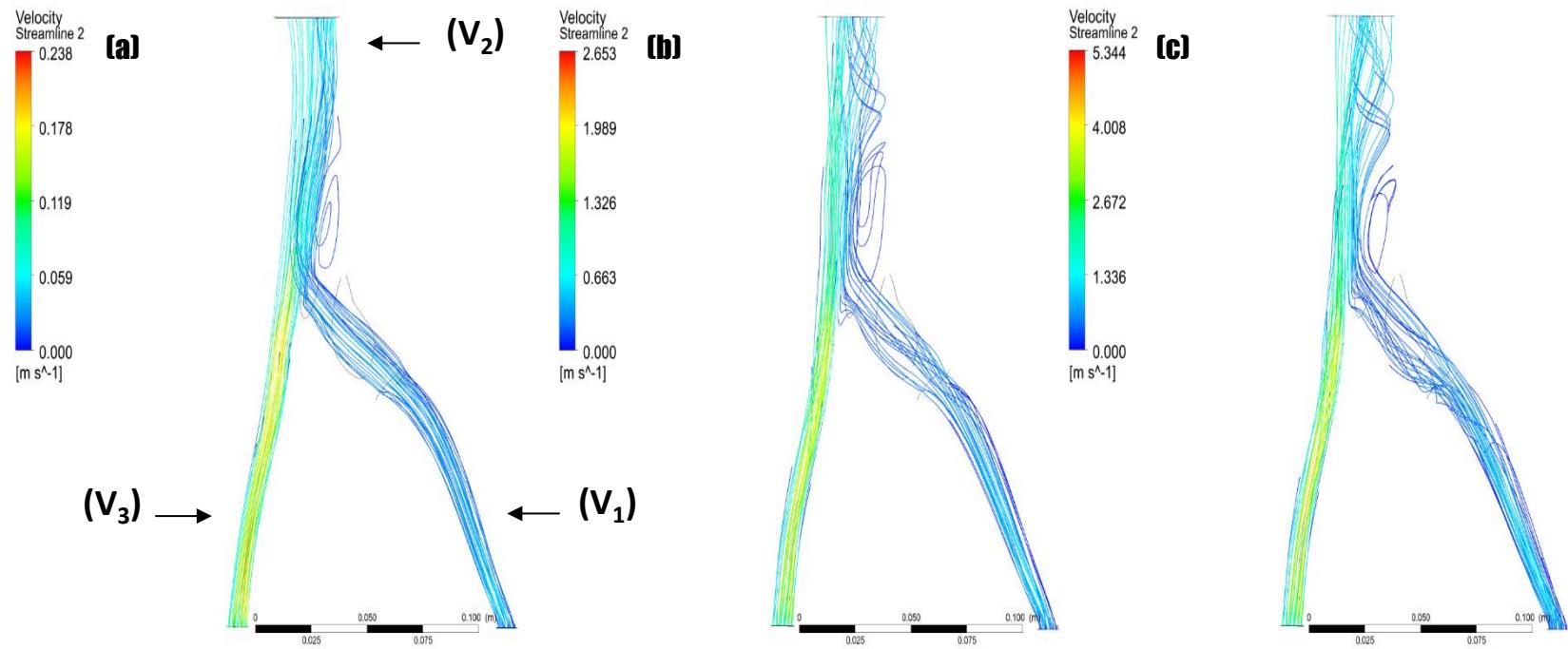


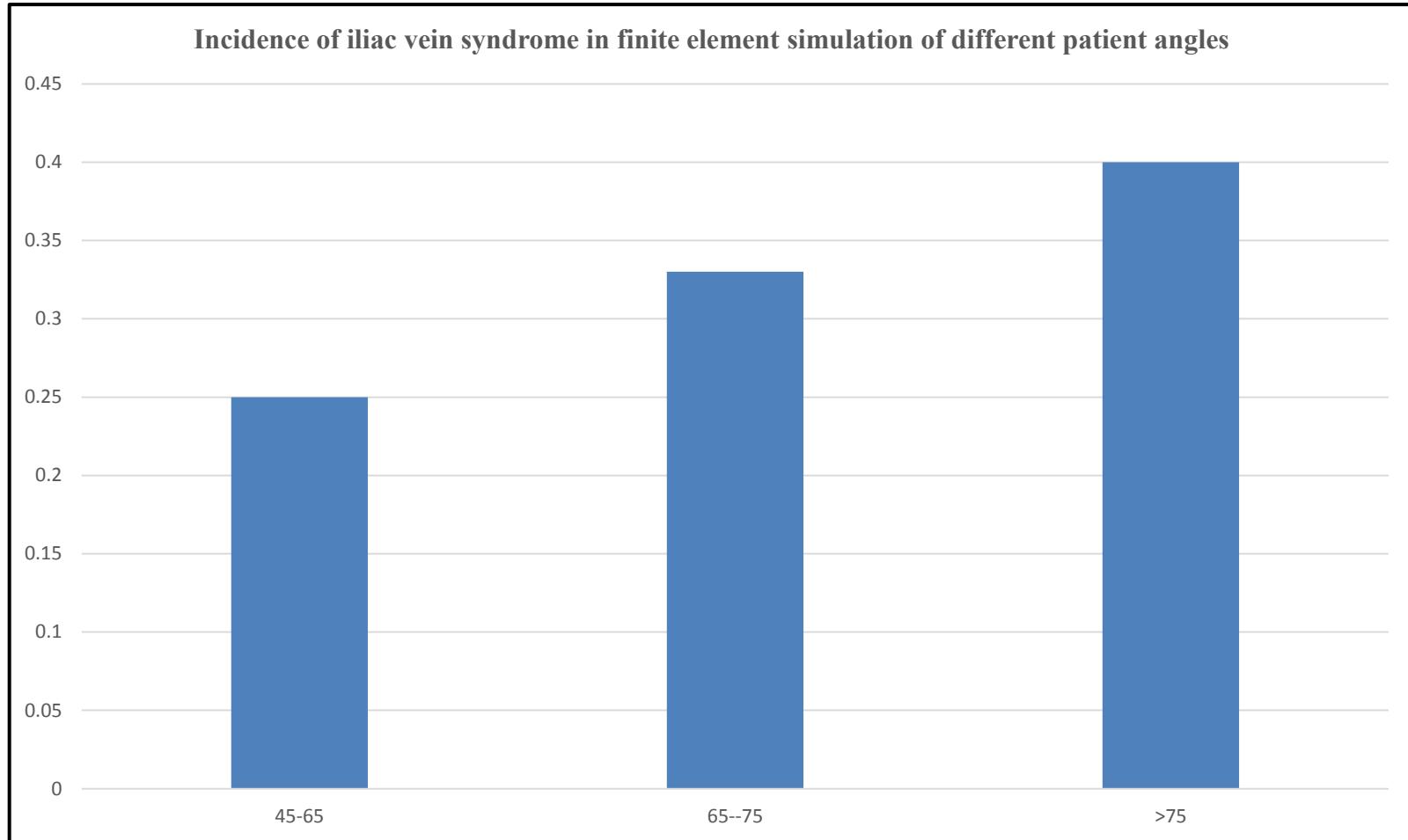
Figure 16. Compare clinical data with simulation models.

(a) $V_1 : V_2 : V_3 = 0.024 : 0.06 : 0.11$

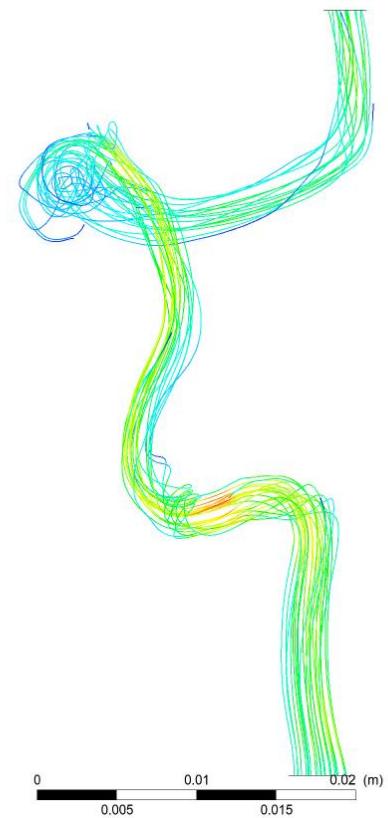
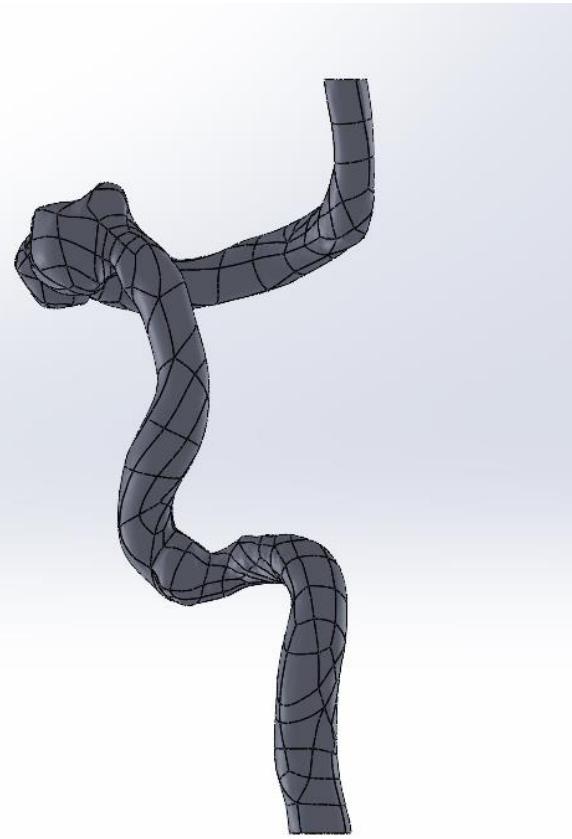
(b) $V_1 : V_2 : V_3 = 0.24 : 0.6 : 1.1$

(c) $V_1 : V_2 : V_3 = 0.48 : 1.2 : 2.2$

具體成果-35位病患統計

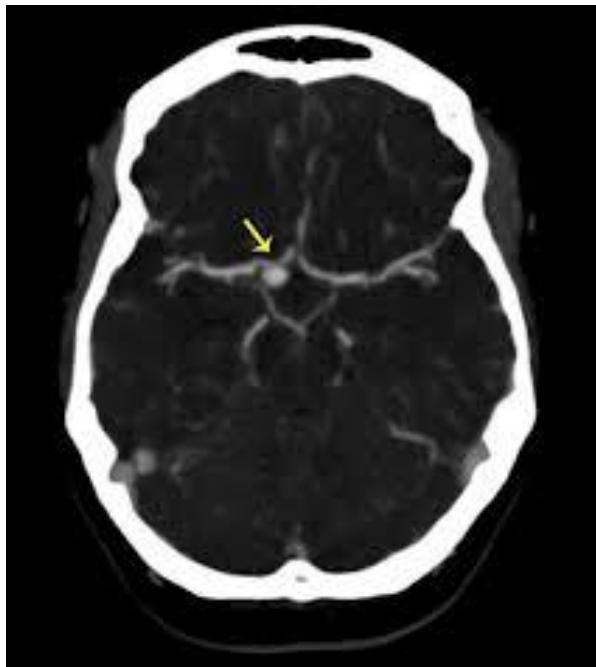


動脈瘤CFD分析



顱內動脈瘤

- 動脈瘤是血管疾病，所以一般要用“血管攝影”才能做最正確的檢查
 - 電腦斷層血管攝影 (CTA)
 - 核磁共振血管攝影 (MRA)



Intracranial aneurysms

What is intracranial aneurysms?

- Refers to a focal outpouching of the arterial wall caused by the vessel wall weakening from a certain etiology.

- Aneurysm is only a morphological description, not a description of the cause.

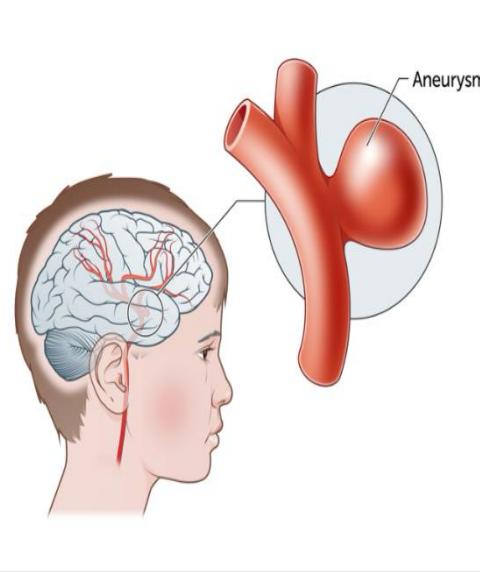


Figure 1. Intracranial aneurysms

Intracranial aneurysms

Causes of intracranial aneurysms

-
- Blood flow impulse at the bifurcation of blood vessel
 - Traumatic
 - Neoplastic
 - Infectious
 - Inflammatory
 - Atherosclerosis

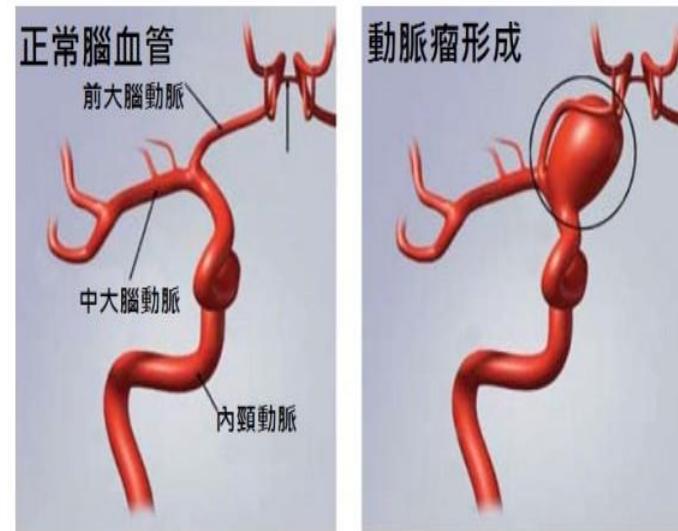


Figure 2. Normal cerebral vessels and aneurysms

Intracranial aneurysms

Intracranial aneurysms effects

- 1. Rupture bleeding - Subarachnoid hemorrhage**
- 2. Compression symptoms – Facial pain, headache,etc.**
- 3. Thrombotic stroke**

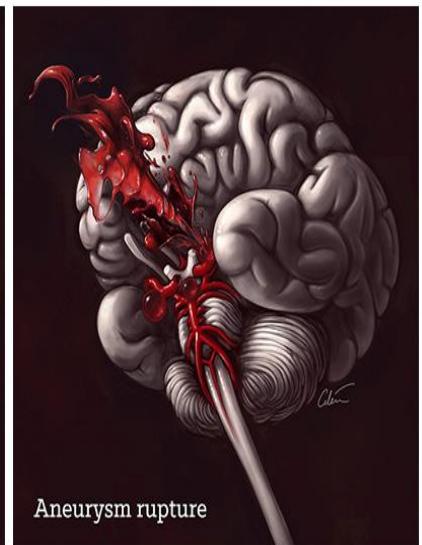
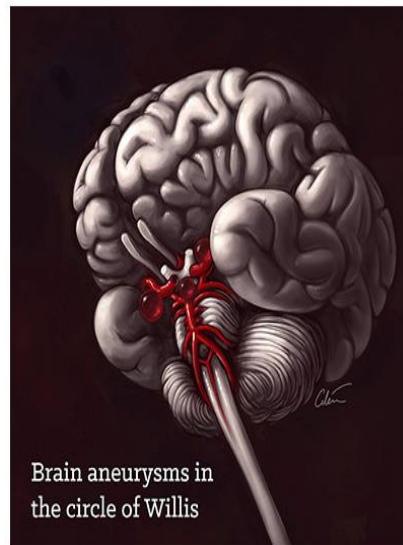


Figure 3. Intracranial aneurysms symptoms.

Intracranial aneurysms

Current treatment

- Endovascular treatment-
by placing the coil in the artery so that
blood can no longer enter the aneurysm
to prevent its continued enlargement.

- Extravascular treatment-clamp the
aneurysm through an aneurysm clamp so
that blood cannot nourish it, and a
drainage tube can be placed to drain bleeding.

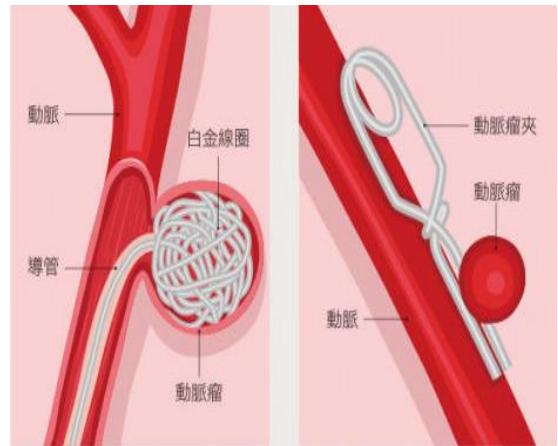


Figure 4. Embolization and craniotomy.

Aneurysm Growth Occurs at Region of Low Wall Shear Stress

Loic Boussel, MD, Vitaliy Rayz, PhD, Charles McCulloch, PhD,
Alastair Martin, PhD, Gabriel Acevedo-Bolton, PhD,
Michael Lawton, MD, Randall Higashida, MD, Wade S. Smith, MD,
PhD, William L. Young, MD, and David Saloner, PhD

Stroke

Volume 39, Issue 11, 1 November 2008; Pages 2997-3002
<https://doi.org/10.1161/STROKEAHA.108.521617>



- Both excess and lack of the stimulus can lead to pathological phenomena that cause changes in the arterial wall biomechanical properties.
 1. High wall shear stress values - damage the layer of endothelial cells.
 2. Low wall shear stress values - generates endothelial proliferation and apoptosis

Research Purpose

Past

- It is generally believed clinically that the formation of aneurysms is related to smoking, high blood pressure and blood vessel damage with age.

This study

- The formation of aneurysms is closely related to blood flow and intravascular stress.
- FEM - used to analyze flow ratio and as a future clinical diagnosis and prediction of the growth of intracranial aneurysms.

Convert CT image to solid model

01

Materialize Mimics



02

Geomagics Design X



03

Solidworks



04

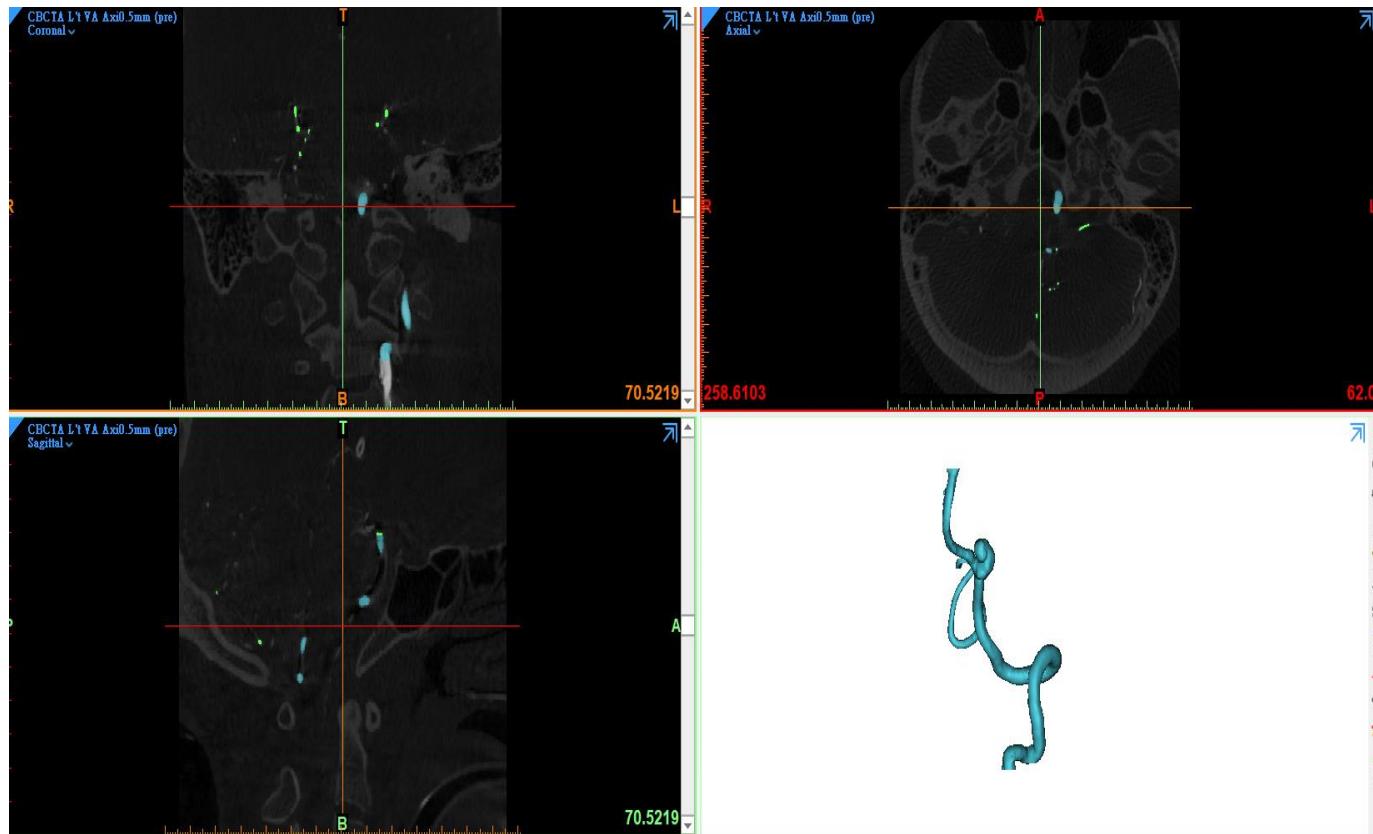
Ansys



Convert CT image to solid model

01

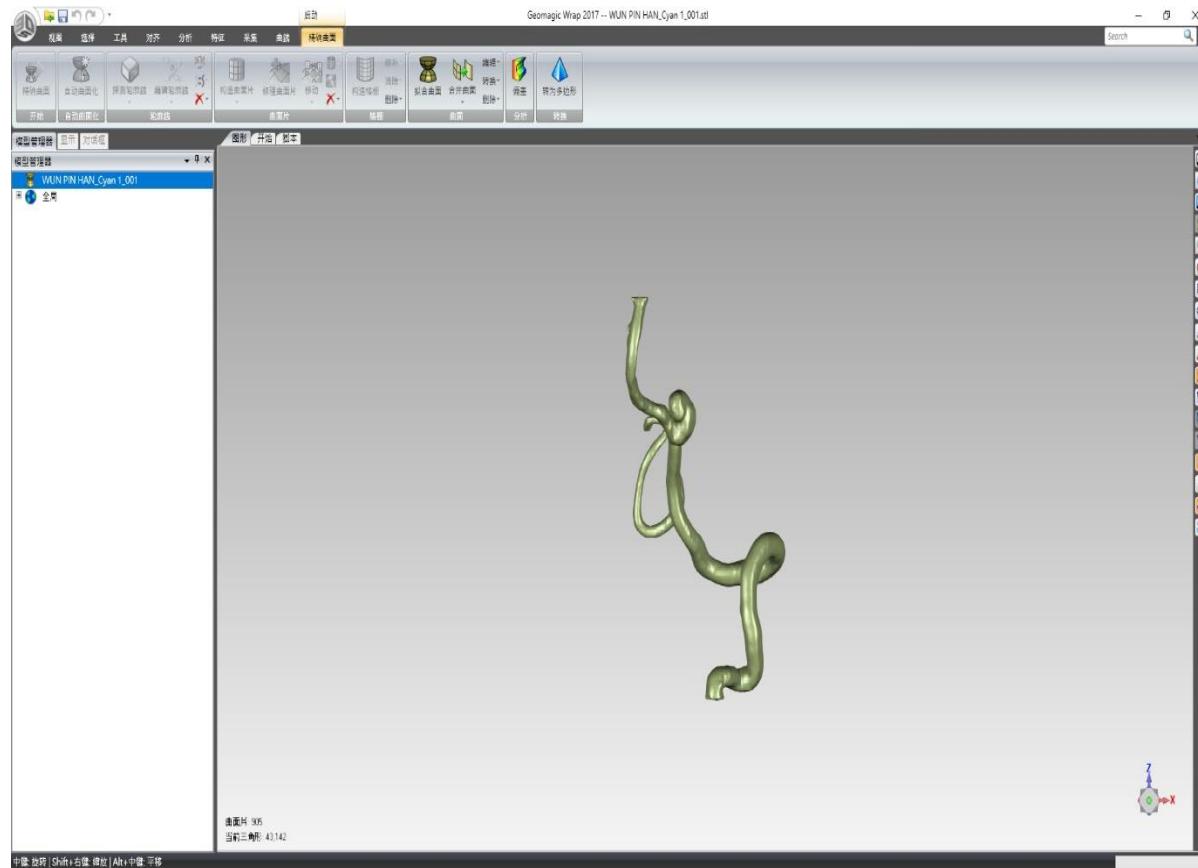
Mimics



Convert CT image to solid model

02

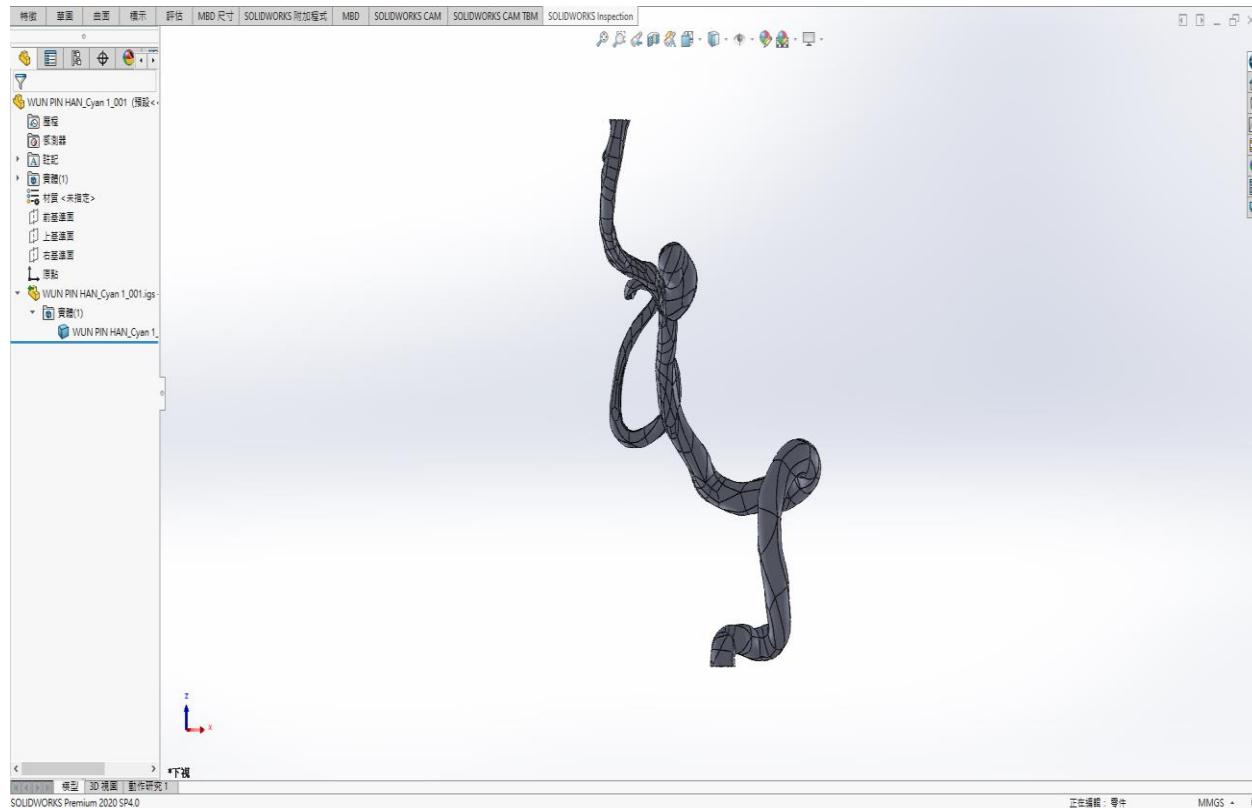
Geomagics



Convert CT image to solid model

03

Solidworks



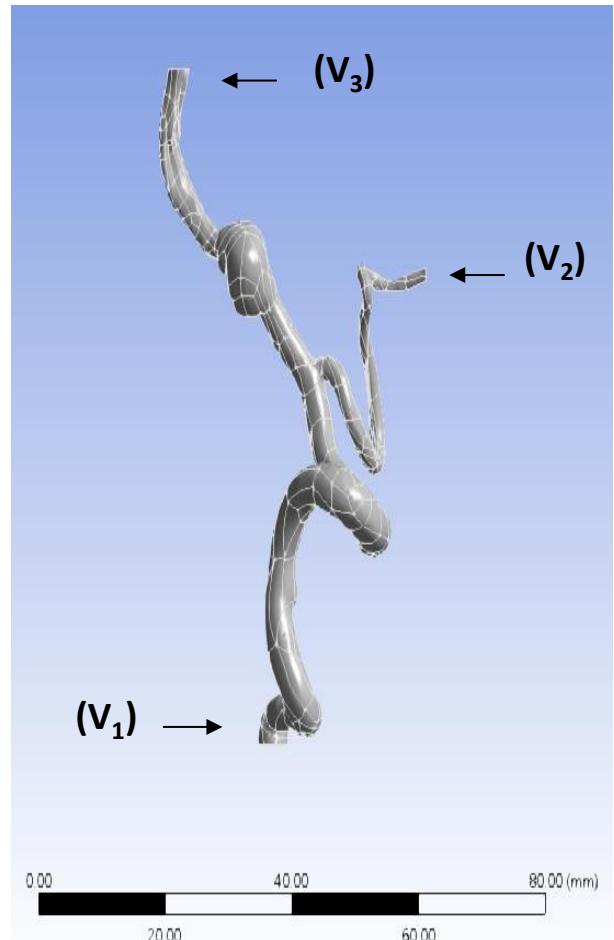
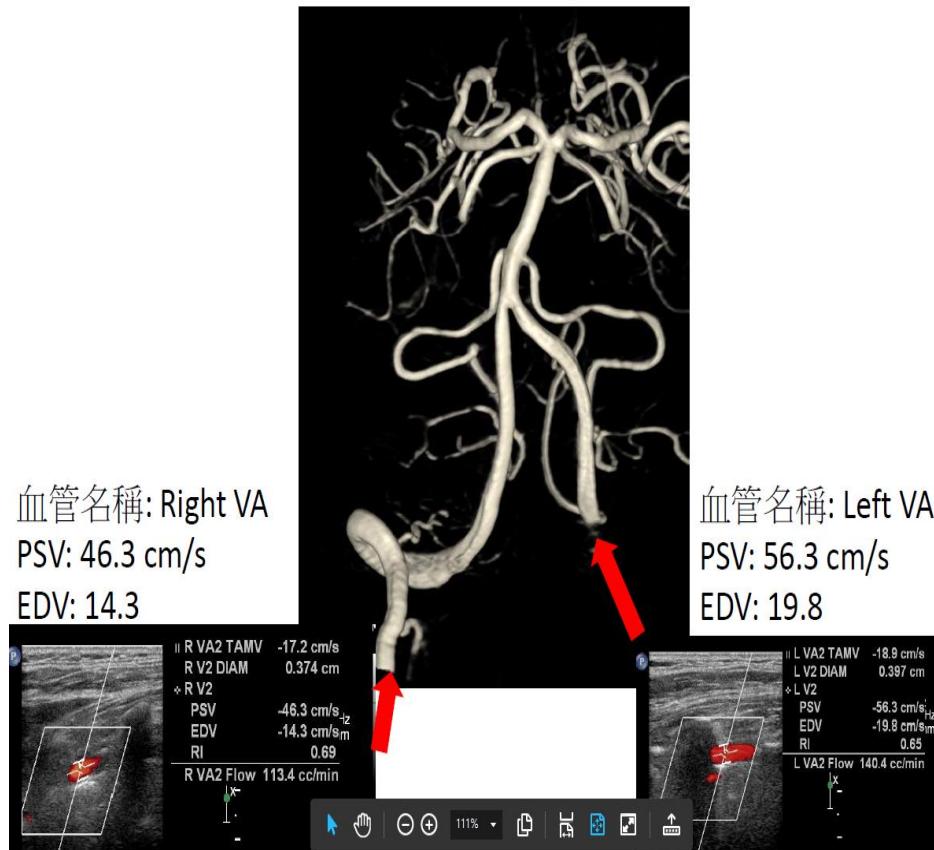
FEM setting

04

Ansys



Blood flow caculation & input



Blood flow caculation & input

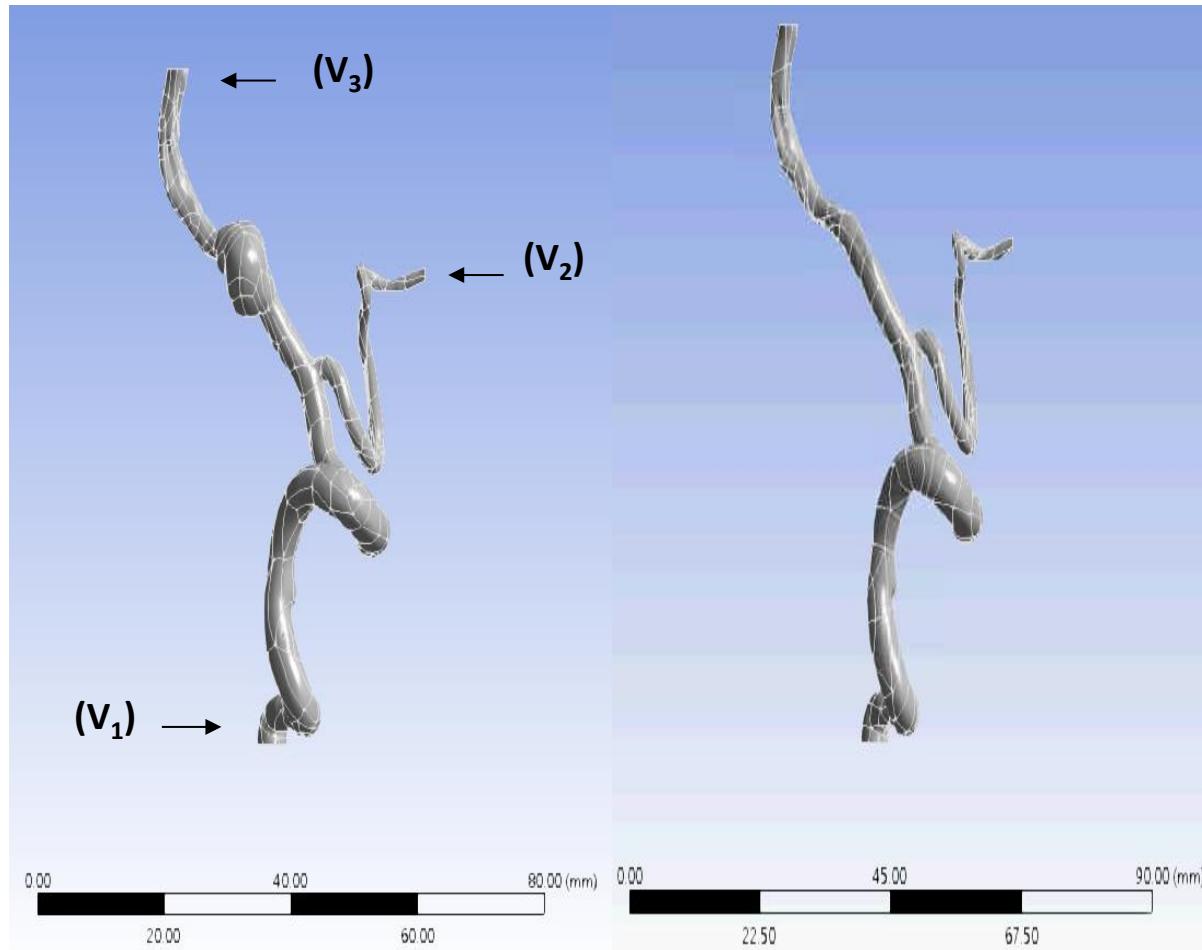


Figure 5. The three-dimensional reconstruction solid model (left) and the finite element model of the resection of the aneurysm (right)

Comparison of real blood vessel angiography and simulation

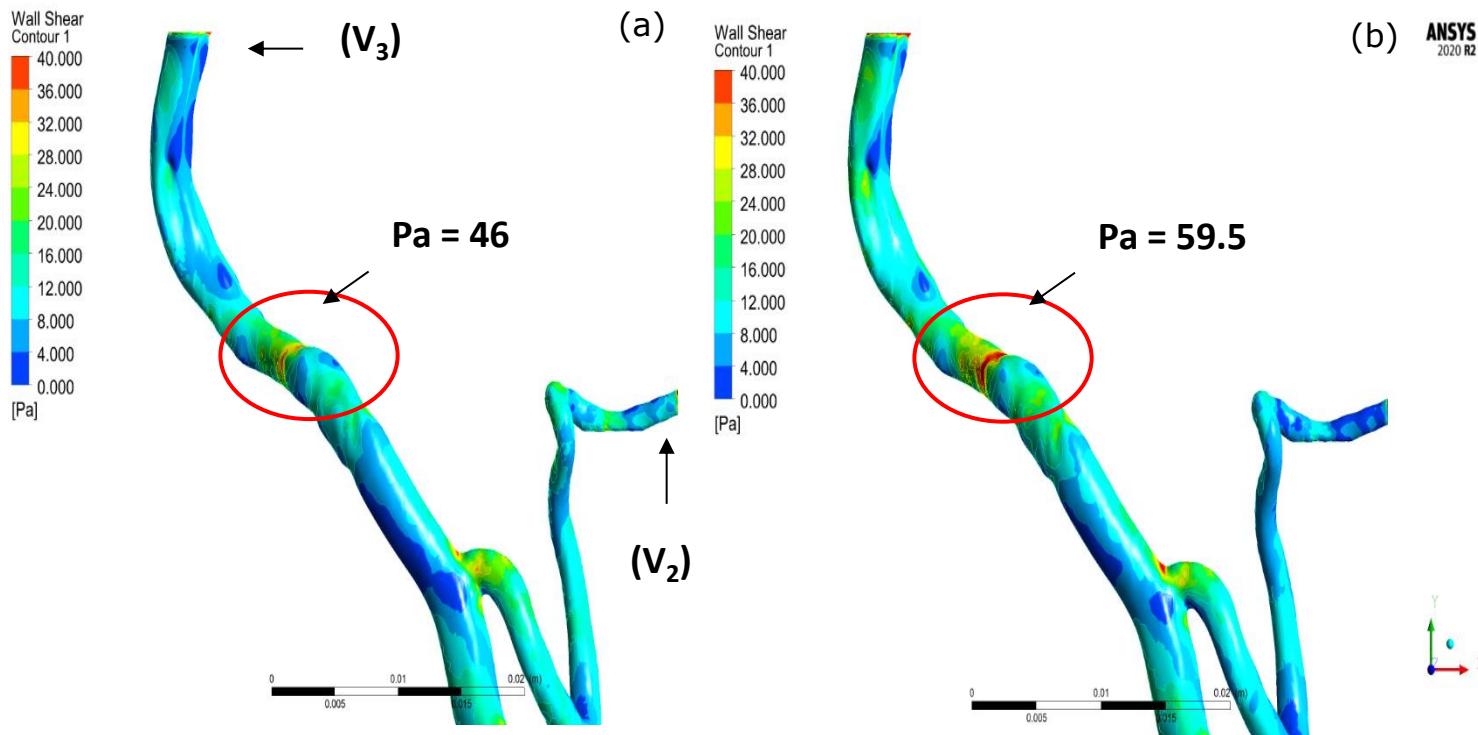
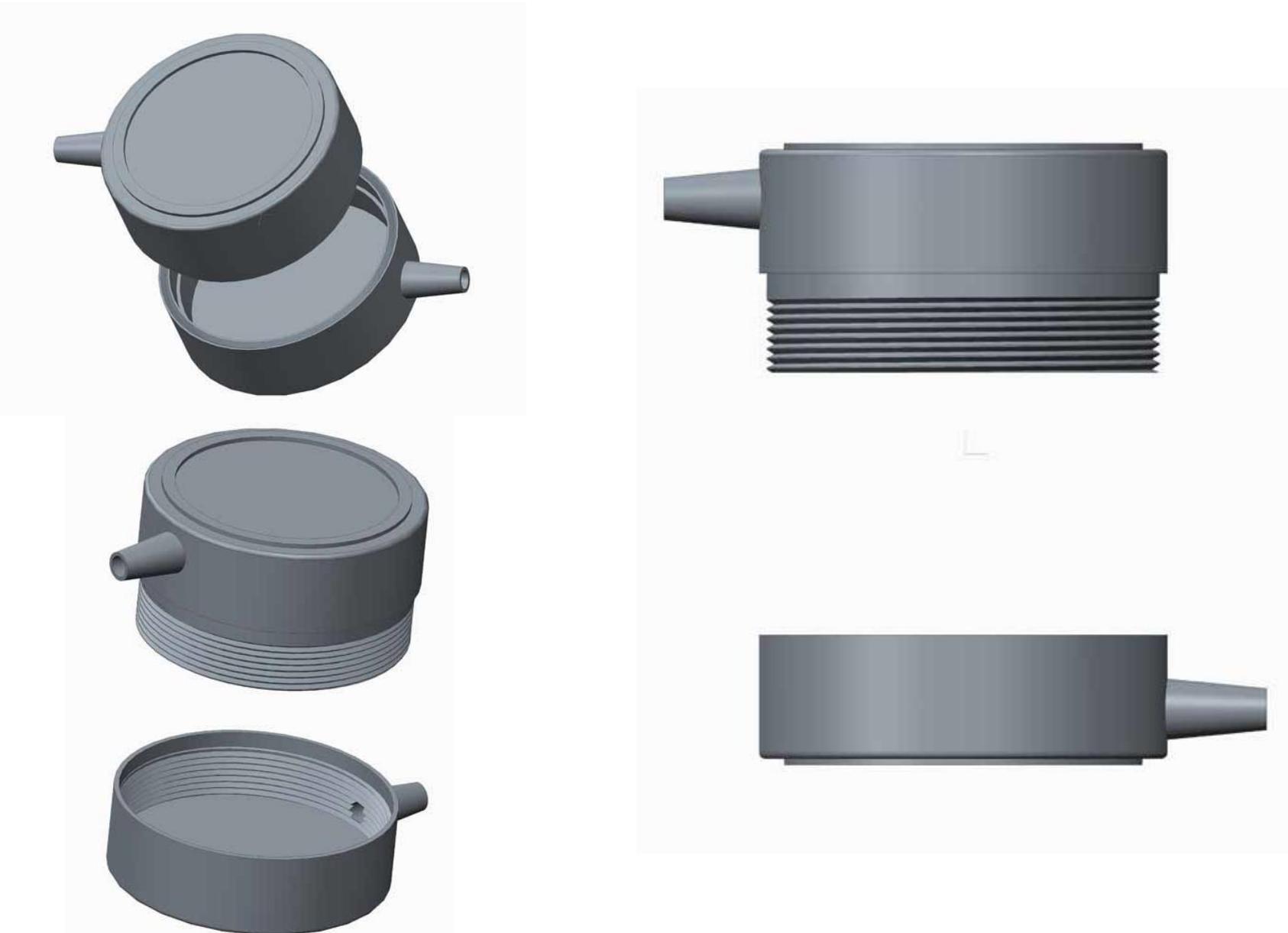


Figure 6. Different inlet and outlet blood flow rate ratio. ($V_1 = 0.563 \text{ m/s}$)
(a) $V_1 : V_2 : V_3 = 5 : 2 : 3$; $Pa = 46 \text{ Pa}$.
(b) $V_1 : V_2 : V_3 = 5 : 1 : 4$; $Pa = 59.5 \text{ Pa}$.

氧氣過濾器 阻抗改進研發





一般醫院的中央供氣壓力是50 PSIG (50 pound/inch²) = 3.5 bar

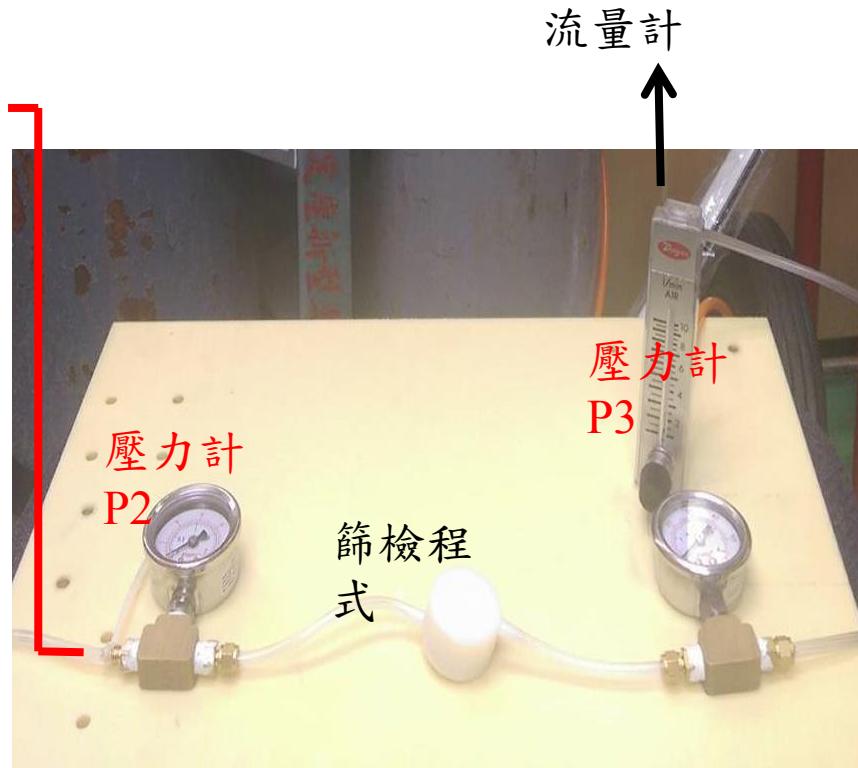
壓力單位

閱·論·編	帕斯卡	巴	工學大氣壓	標準大氣壓	托(毫米水銀柱)	磅力每平方英寸
	Pa	bar	at	atm	Torr	psi
1 Pa	$\equiv 1 \text{ N/m}^2$	10^{-5}	1.0197×10^{-5}	9.8692×10^{-6}	7.5006×10^{-3}	145.04×10^{-6}
1 bar	10^5	$\equiv 10^6 \text{ dyn/cm}^2$	1.0197	0.98692	750.06	14.5037744
1 at	0.980665×10^5	0.980665	$\equiv 1 \text{ kp/cm}^2$	0.96784	735.56	14.223
1 atm	1.01325×10^5	1.01325	1.0332	$\equiv p_0$	760	14.696
1 Torr	133.322	1.3332×10^{-3}	1.3595×10^{-3}	1.3158×10^{-3}	$= 1 \text{ mmHg}$	19.337×10^{-3}
1 psi	6.895×10^3	68.948×10^{-3}	70.307×10^{-3}	68.046×10^{-3}	51.715	$\equiv 1 \text{ lb/in}^2$

實驗設備與結構



空氣鋼瓶



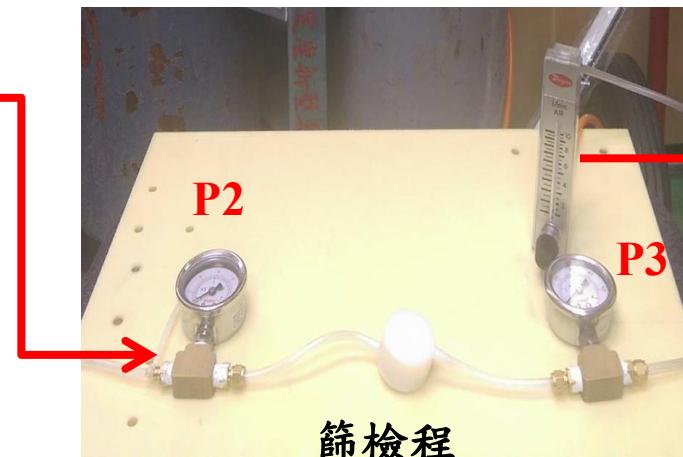
實驗模組

控制流量以測試各點壓力值（有洩漏時）

	壓力	6 (LPM)	8(LPM)	
8	P1	0.5 kg/cm ² (7.5 PSI)	1 kg/cm ² (15 PSI)	←
	P2	0.3 kg/cm ² (5 PSI)	0.7 kg/cm ² (10 PSI)	
	P3	0.1 kg/cm ² (1.5 PSI)	0.5kg/cm ² (7.5 PSI)	



一般醫院的中央
供氣壓力是**50**
PSI



流量計

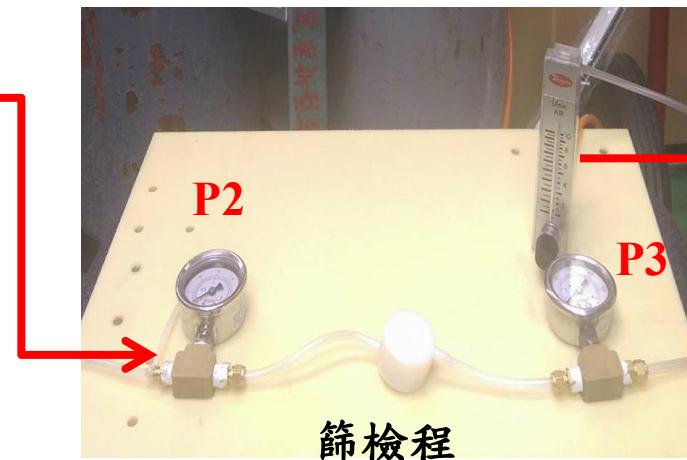
篩檢程
式

控制流量以測試各點壓力值(無洩漏時)

	壓力	6 (LPM)	8(LPM)
8	P1	0.3 kg/cm² (4.5 PSI)	0.8 kg/cm² (12 PSI)
	P2	0.1 kg/cm² (1.5 PSI)	0.5 kg/cm² (7.5 PSI)
	P3	>0.1 kg/cm² (>1.5 PSI)	0.3kg/cm² (4.5 PSI)

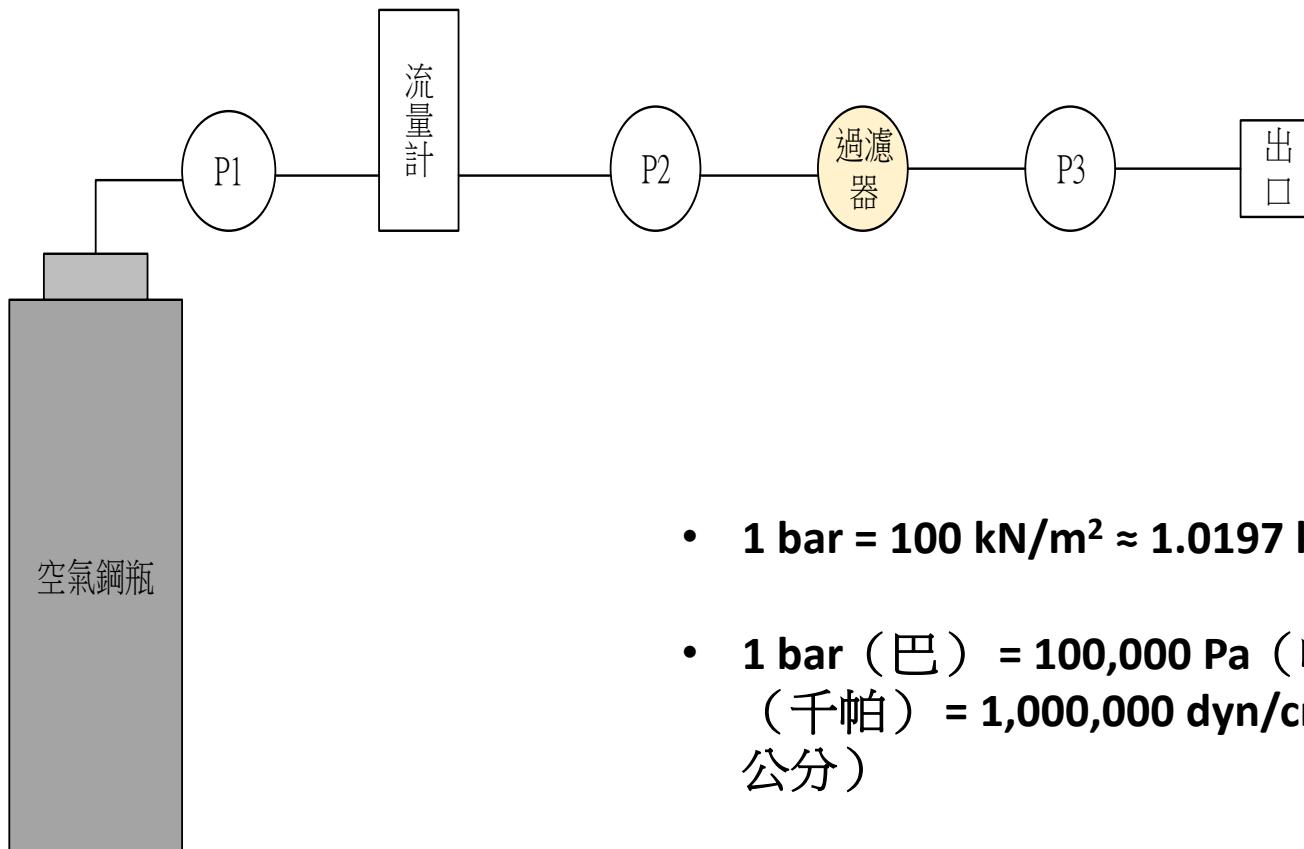


一般醫院的中央
供氣壓力是**50**
PSI



實驗一：篩檢程式內部各元件造成 的影響

實驗設備與結構



圖一 實驗結構圖

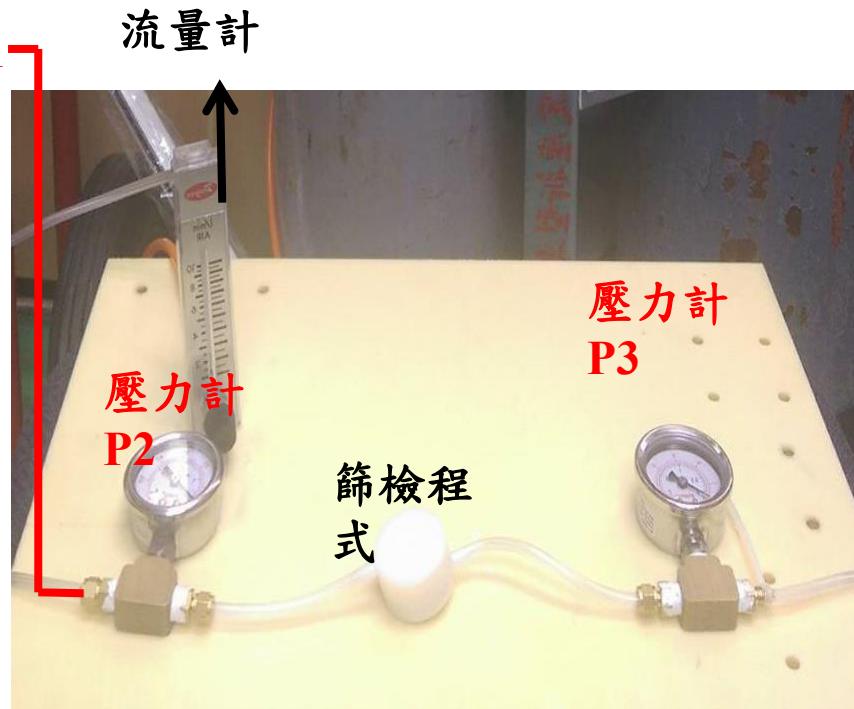
- **1 bar = 100 kN/m² ≈ 1.0197 kgf/cm²**
- **1 bar (巴) = 100,000 Pa (帕) = 100 kPa
(千帕) = 1,000,000 dyn/cm² (達因/平方公分)**
- **1 mbar (毫巴) = 0.001 bar (巴) = 0.1 kPa
(千帕) = 1 hPa (百帕) = 1,000 dyn/cm²
(達因/平方公分)**

實驗設備與結構



壓力計 P1

空氣鋼瓶

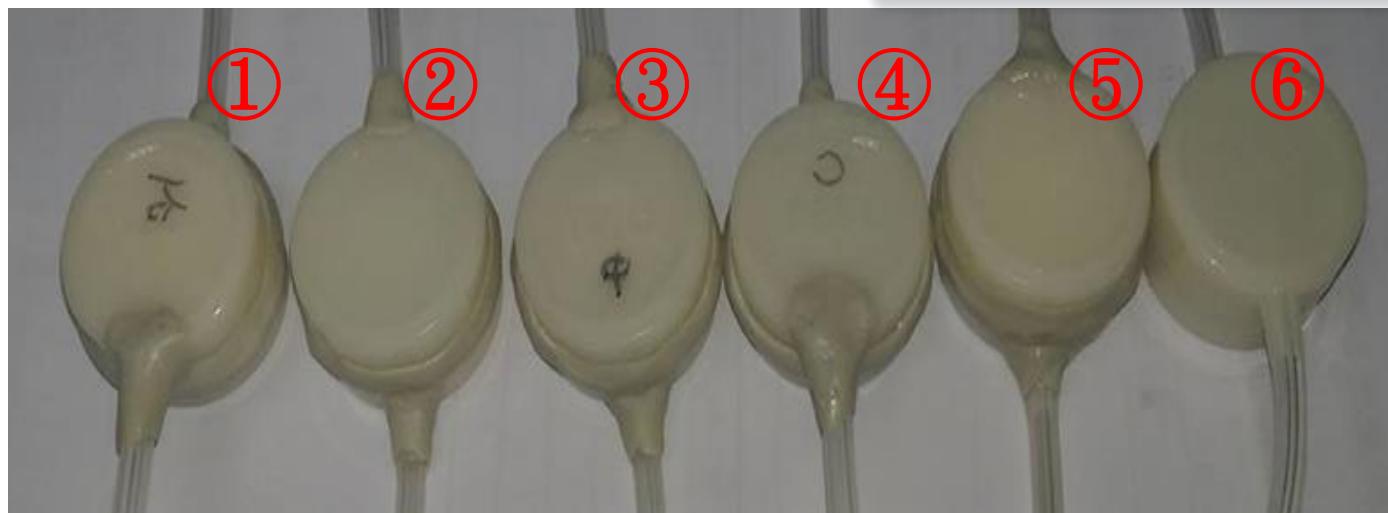
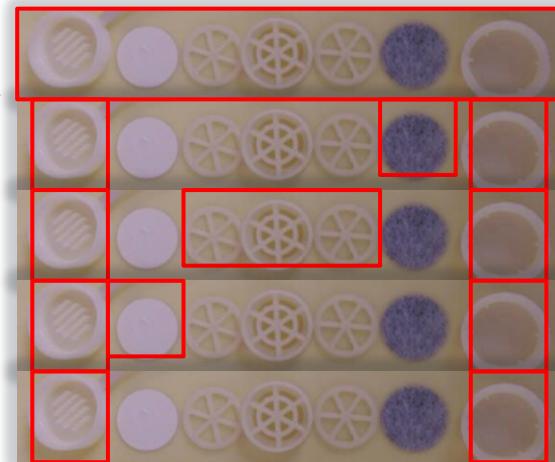


實驗模組

空氣鋼瓶

控制流量以測試各點壓力值

- ①: 初始組件
- ②: 以塑鋼土密封之完整元件
- ③: 裝有活性碳濾片之濾器
- ④: 安裝中間支架
- ⑤: 裝有石綿濾片之濾器無
- ⑥: 安裝組件



圖六 篩檢程
式

篩檢程式各組件對出口壓力之影響



圖七 內部結構圖

- ①: 石棉濾片
- ②: 上墊
- ③: 中間架子
- ④: 下墊
- ⑤: 活性碳濾片

篩檢程式各組件對出口壓力之影響



塑鋼土黏合



瞬間膠黏合



塑鋼土+瞬間膠黏合



金屬濾器



裝有不同組件之密封篩檢程式

控制流量以測試各點壓力值

P1:氣瓶壓力 P2:進口壓力值 P3:出口壓力值

單位:kg/cm²

流量控制對篩檢程式之影響

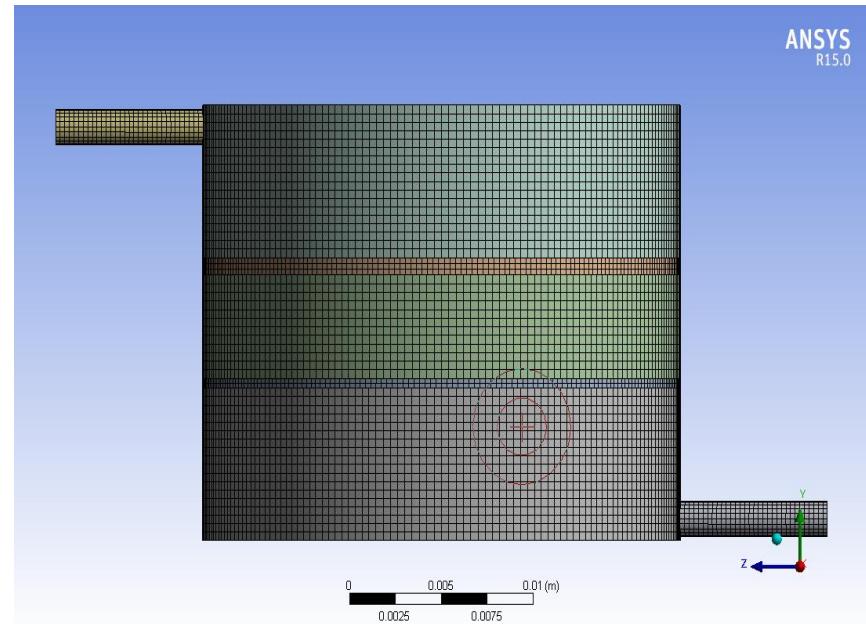
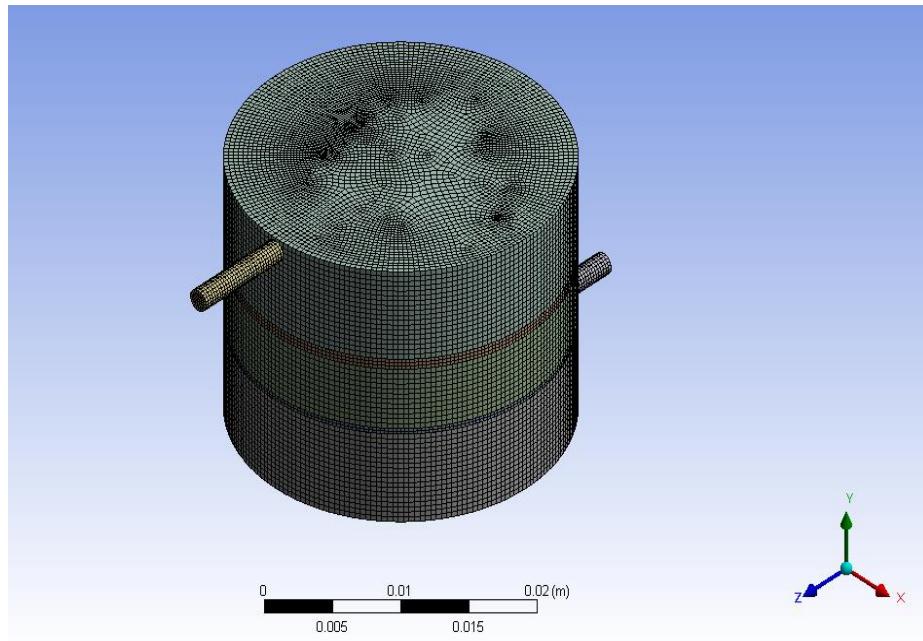
流量 (LPM)	壓力	①	②	③	④	⑤	⑥
8	P1	0.5	0.5	0.5	0.5	0.5	0.5
	P2	0.2	0.2	0.2	0.2	0.2	0.2
	P3	0.05	0.05	小於0.1	接近0.1	小於0.1	0.1

篩檢程式各組件對出口壓力之影響

實驗組別	內部組件	P2 (kg/cm ²)	P3 (kg/cm ²)	備註
1	完整元件	1	0.3	塑鋼土黏合
2		1	0.3	瞬間膠黏合
3		1	0.3	塑鋼土+瞬間膠黏合
4		1	0.25	金屬濾器
5	③⑤	1	接近0.35(小於)	活性碳濾片+中間架子
6	①③	1	0.32~0.33	石綿濾片+中間架子
7	③	1	0.35	中間架子
8	無組件	1	0.35	上蓋+下蓋

壓差損失65-70%

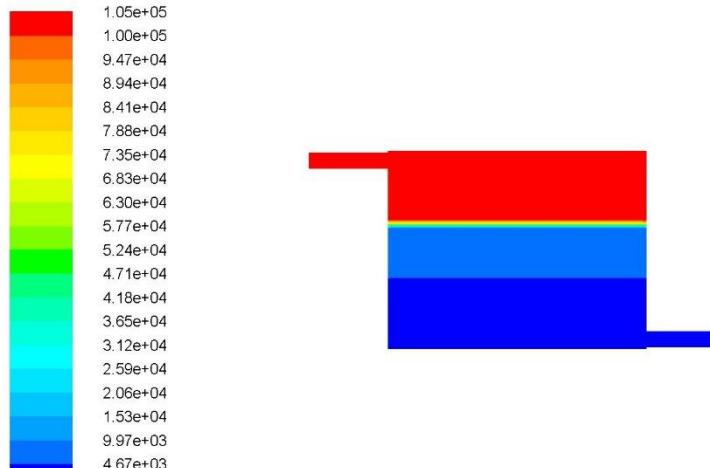
濾清器電腦模型建立



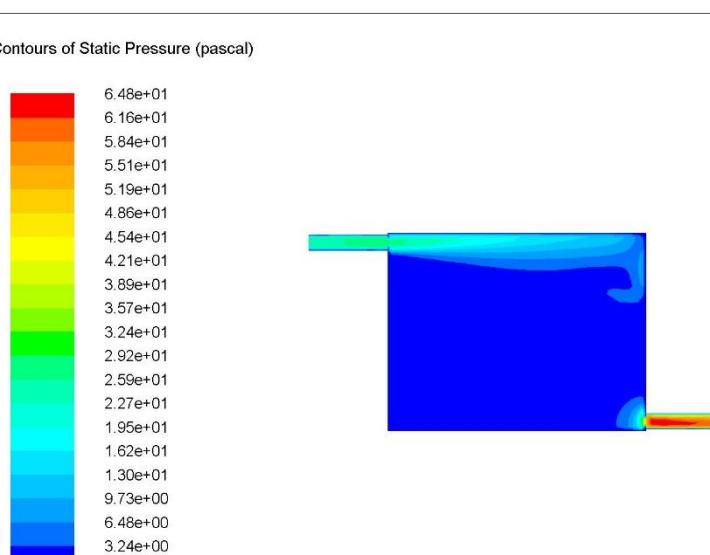
尋找濾材參數

濾清器原型尺寸下，進行定流量3 L/min條件下，入口端的流速為25 m/s

流量 3 L/min	inlet=25 m/s
原始尺寸	
CASE A	壓力(pascal)
inlet-pipe	105240.0
top	105176.4
asbestos	65040.7
mid	9791.9
carbon	6311.1
bottom	2713.4
outlet-pipe	105.0
進/出口壓降	105135.0
	孔隙參數
asbestos	6E+13
carbon	5E+12



原尺寸濾清器含濾材(定流量)壓力剖面圖

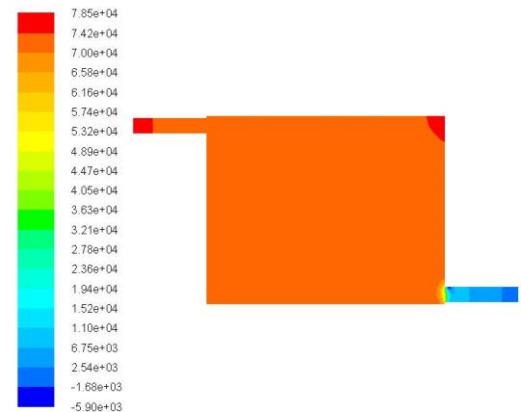


原尺寸濾清器含濾材(定流量)速度剖面圖

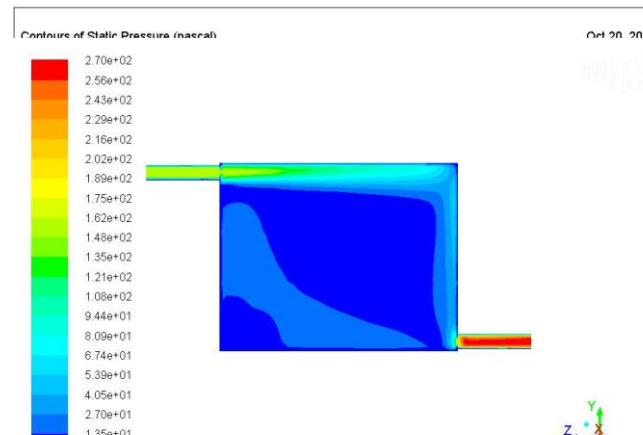
驗證模型的「準確性」

入口壓力	1bar
原始尺寸	無濾材
CASE A	壓力(pascal)
inlet-pipe	73303.5
top	71556.2
asbestos	71422.9
mid	71405.9
carbon	71414.2
bottom	71524.4
outlet-pipe	5350.8
進出口壓降	67952.7
孔隙參數	
asbestos	0
carbon	0

空殼濾清器-壓力差值表



濾清器原型(定壓)壓力剖面圖

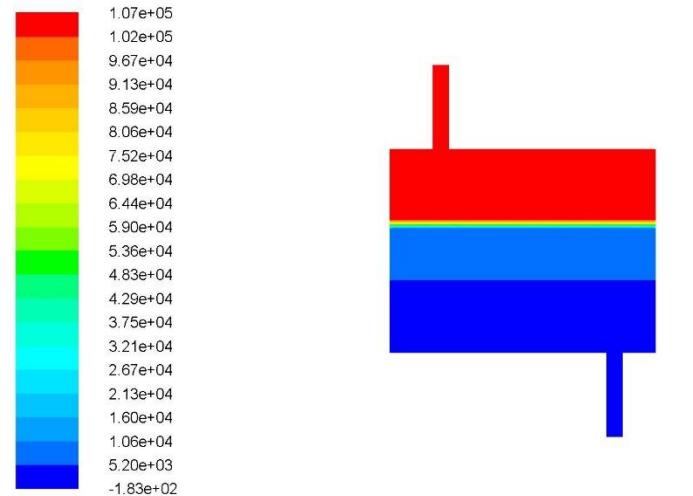


濾清器原型(定壓)速度剖面圖

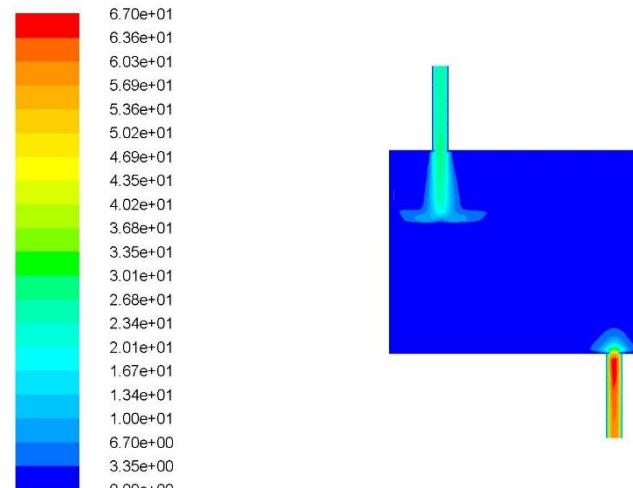
濾清器原型(定壓-入口壓力1bar)，可得入/出口的壓力差值為0.679 bar (70%)，與實驗相比，誤差小於3%，此數值模擬與實驗資料有相似的結果，也進而驗證了此數值模擬的「準確性」。

濾清器修改入出口端位置

流量 3 L/min	inlet=25 m/s
改變進出口位置	
CASE B	壓力(pascal)
inlet-pipe	106796.1
top	106711.8
asbestos	66132.1
mid	10248.3
carbon	6689.4
bottom	3010.4
outlet-pipe	121.1
進/出口壓降	106675.0
	孔隙參數
asbestos	6E+13
carbon	5E+12



Contours of Static Pressure (pascal)



Contours of Velocity Magnitude (m/s)

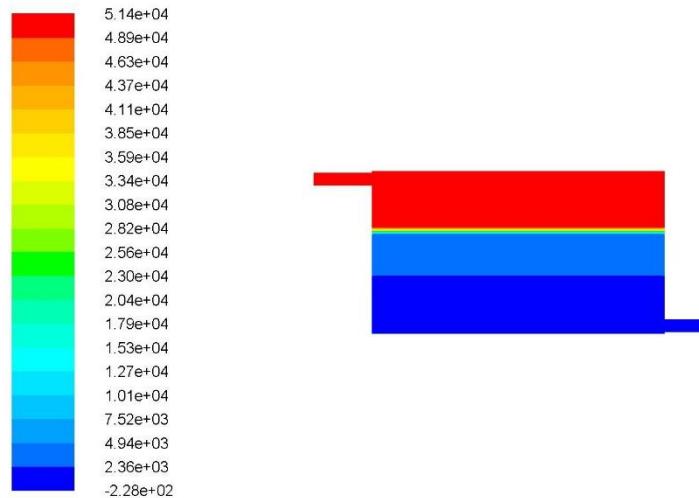
進/出口端的壓差值仍為1 bar,
濾清器內部的壓力分佈差異不大

濾清器入/出口
端位置更改(定
流量)壓力剖面
圖

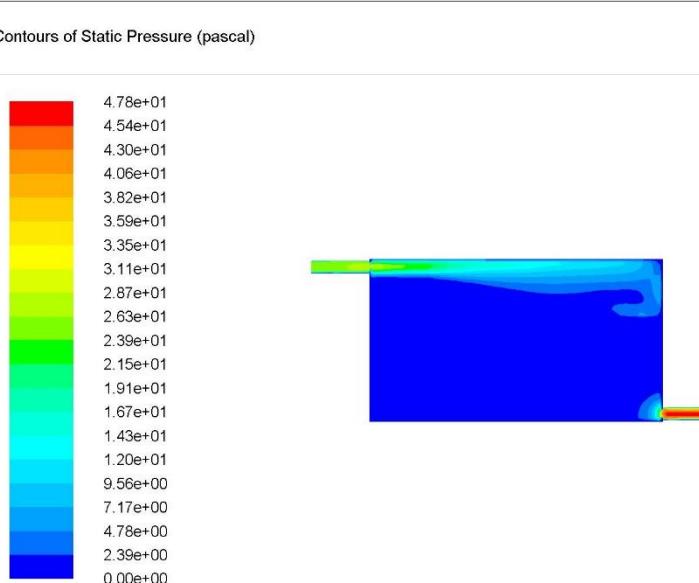
濾清器入/出
口端位置更改
(定流量)速度
剖面圖

濾清器本體直徑增加

流量 3 L/min	inlet=25 m/s
本體圓柱直徑改36mm	
CASE C	壓力(pascal)
inlet-pipe	51395.3
top	51321.4
asbestos	30440.2
mid	4418.4
carbon	3008.2
bottom	1575.5
outlet-pipe	63.7
進/出口壓降	51331.5
	孔隙參數
asbestos	6.00E+13
carbon	5.00E+12



濾清器圓柱體直
徑增加(定流量)
壓力剖面圖



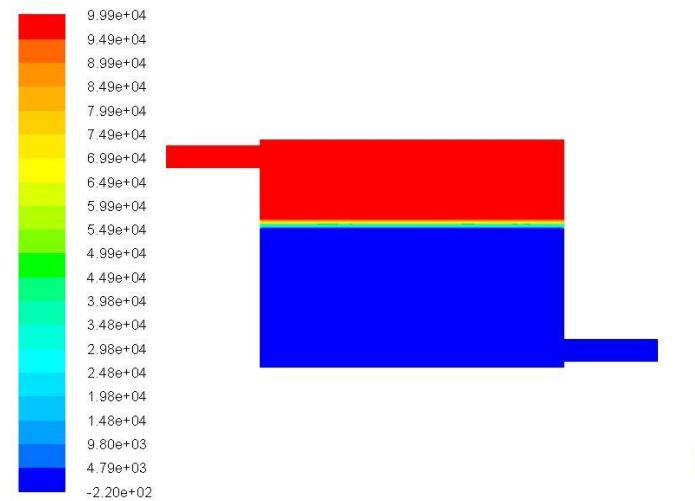
濾清器圓柱體直
徑增加(定流量)
速度剖面圖

相較原模型的壓差少了0.5 bar的
壓力值，由此可觀察到將圓柱整
體尺寸放大是有效降低壓降值。

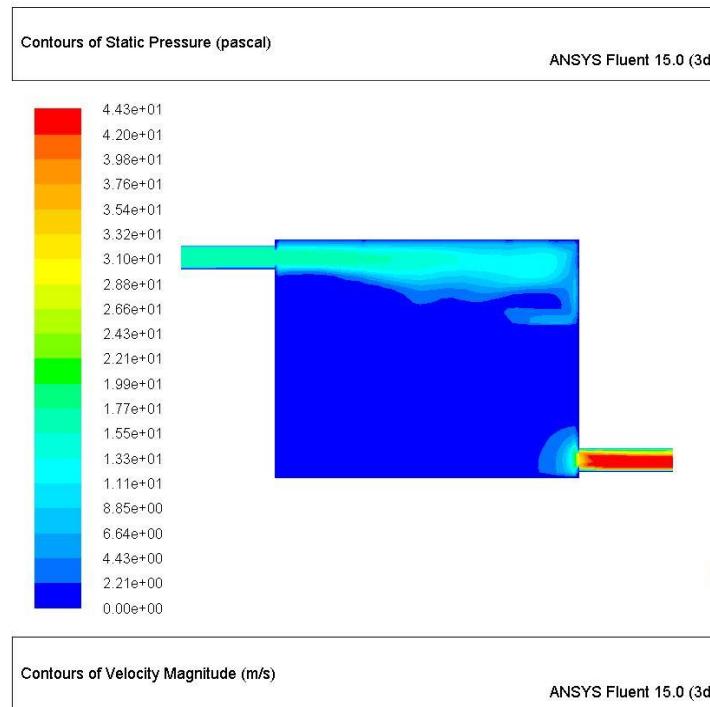
濾清器入/出口管直徑增加

流量 3 L/min	inlet=16 m/s
進出口管徑改2mm	
CASE D	壓力(pascal)
inlet-pipe	99807.7
top	99788.4
asbestos	59203.9
mid	2083.0
carbon	1581.0
bottom	1072.0
outlet-pipe	18.5
進出口壓降	99789.2
孔隙參數	
asbestos	6.00E+13
carbon	5.00E+12

加大管徑模型的前後壓差值
仍維持在1 bar，與原模型的
壓降相似。



濾清器入/出口管
直徑增加(定流量)
壓力剖面圖

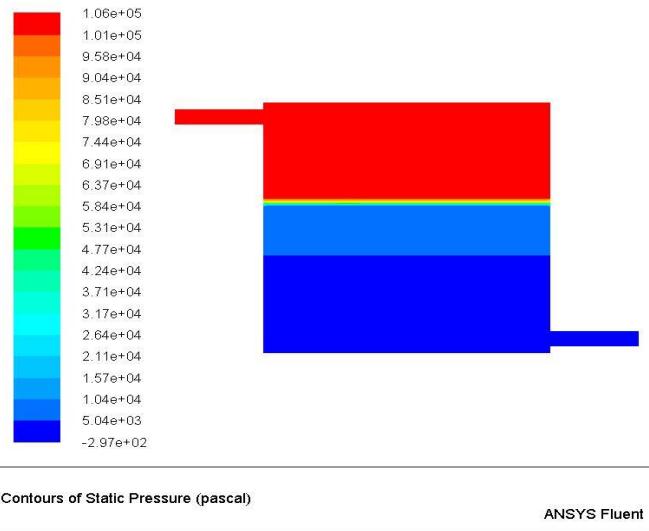


濾清器入/出口管
直徑增加(定流量)
速度剖面圖

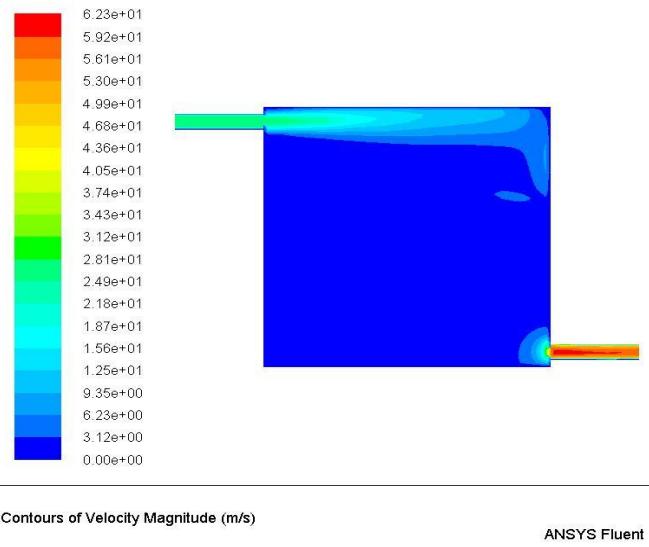
篩檢程式上下蓋高度增加(濾材尺寸不變)

流量 3 L/min	inlet=25 m/s
上下空氣層厚度改10mm(原7mm)	
CASE E	壓力(pascal)
inlet-pipe	106373.5
top	106257.6
asbestos	66605.5
mid	10177.1
carbon	6672.3
bottom	3027.9
outlet-pipe	129.5
進出口壓降	106244.0
	孔隙參數
asbestos	6.00E+13
carbon	5.00E+12

增加上下蓋的容積，不更改濾材尺寸進行模擬分析，觀察到前後端的壓差值仍維持在1 bar



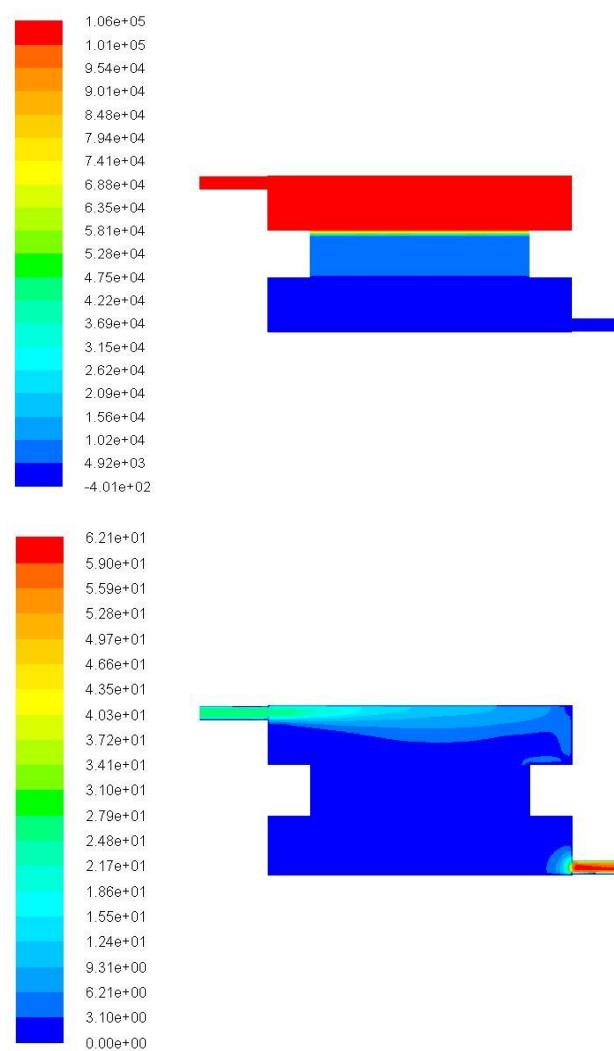
濾清器上/下蓋高度增加(定流量)
壓力剖面圖



濾清器上/下蓋高度
增加(定流量)壓力
剖面圖

篩檢程式上下蓋直徑增加(濾材尺寸不變)

流量 3 L/min	inlet=25 m/s
上下空氣層直徑改3.6mm	
CASE F	壓力(pascal)
inlet-pipe	105964.7
top	105852.6
asbestos	66323.5
mid	10050.9
carbon	6560.1
bottom	2930.9
outlet-pipe	111.4
進出口壓降	105853.3
孔隙參數	
asbestos	6.00E+13
carbon	5.00E+12

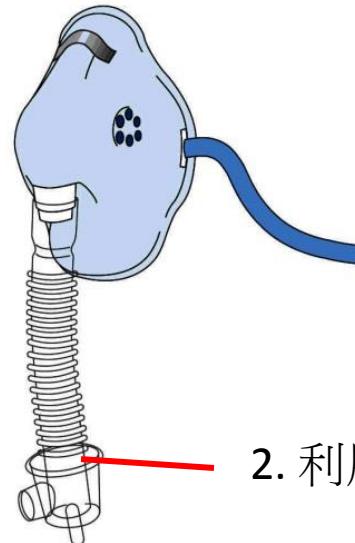
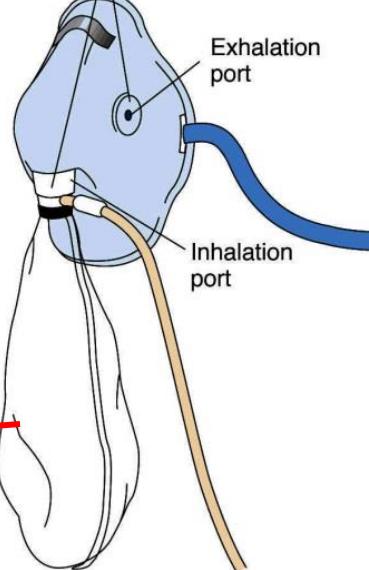
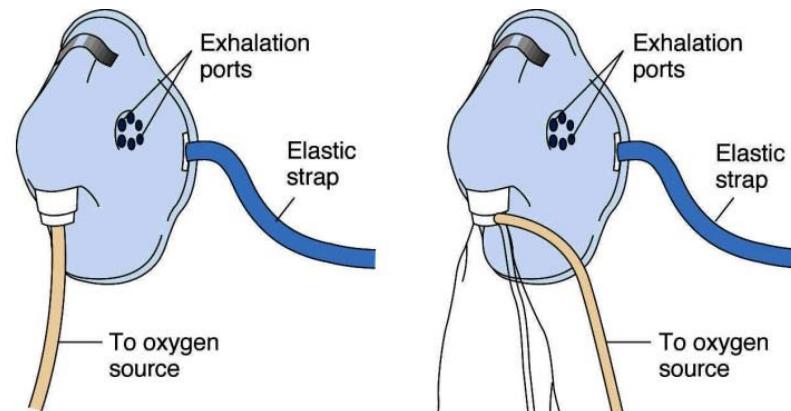


濾清器上/下蓋直徑
增加(定流量)壓力
剖面圖

濾清器上/下蓋直徑
增加(定流量)速度剖
面圖

將上下蓋直徑增加，過濾材維持原尺寸的條件下進行模擬分析，可觀察到入出口的前後端仍維持1 bar壓降差值。

控制氧氣管量的氧氣面罩



1. 利用儲氣裝置



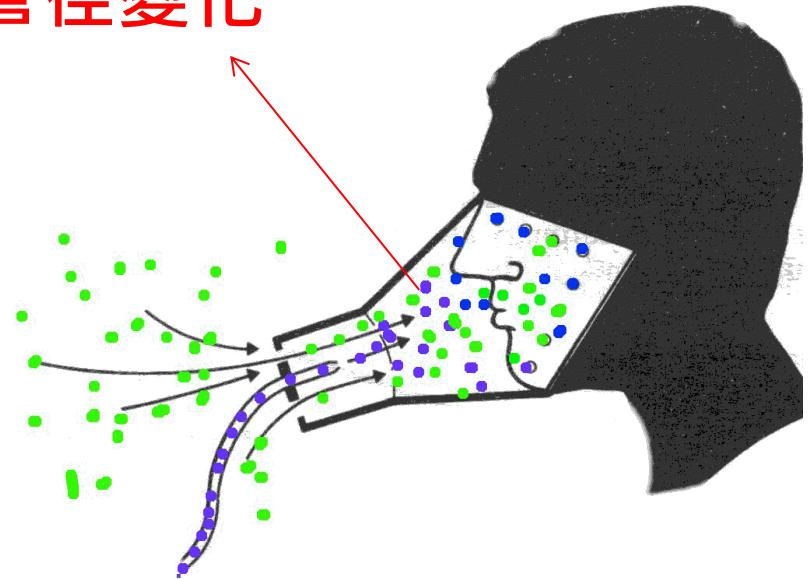
2. 利用柏努力定理



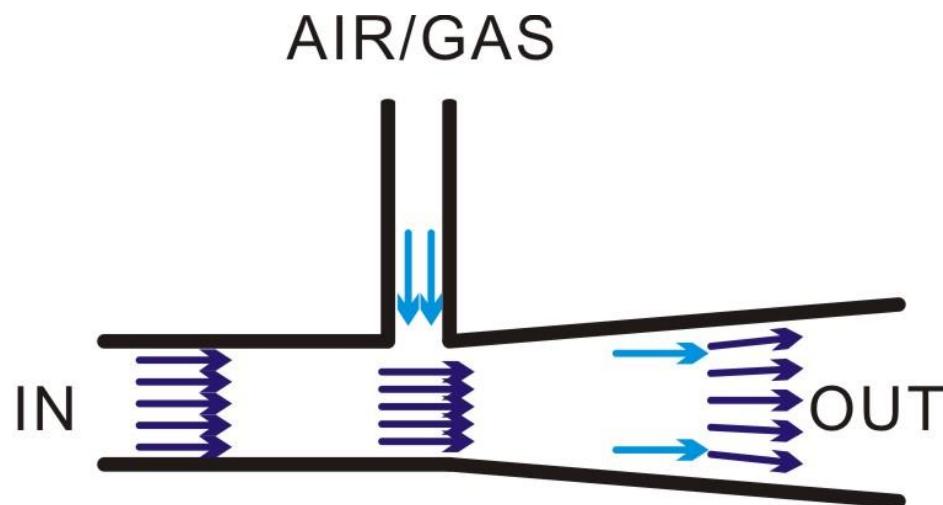
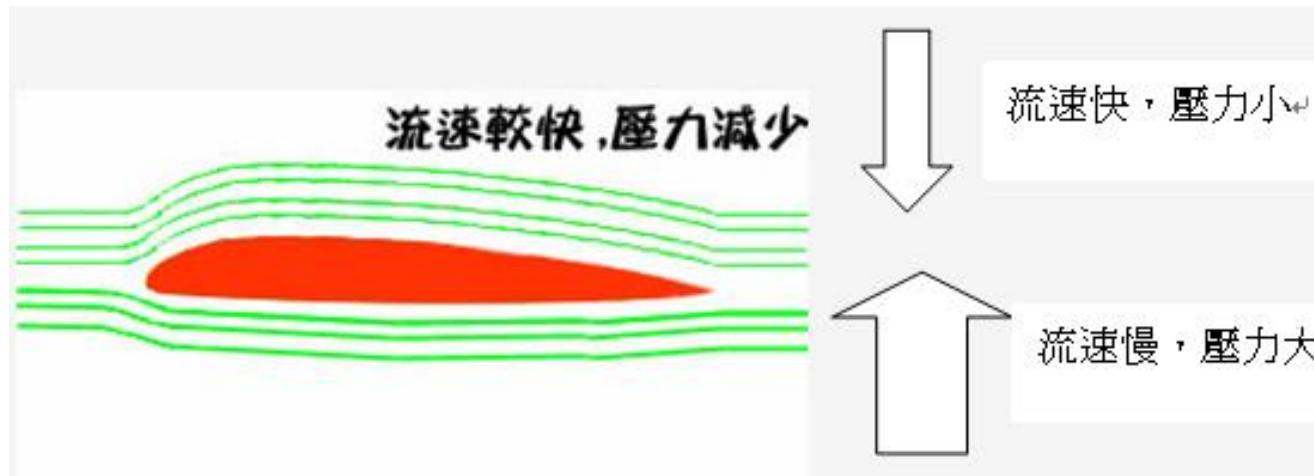
1. 簡單式面罩(Simple mask)：供應流速6-10L/min，可以提供35-55%濃度的氧氣，流速至少6L/min以上，避免面罩內的二氧化碳再吸入。



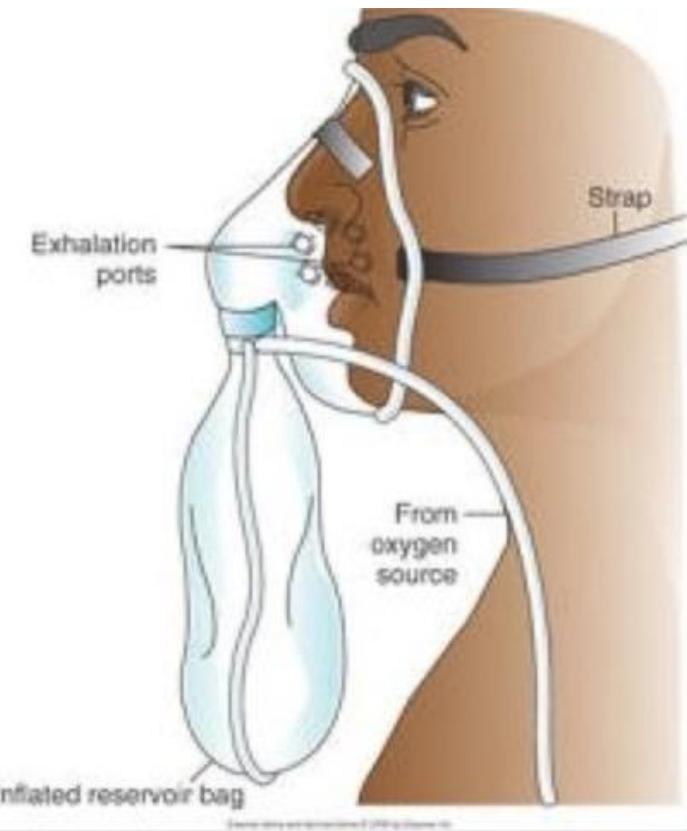
提供管徑變化



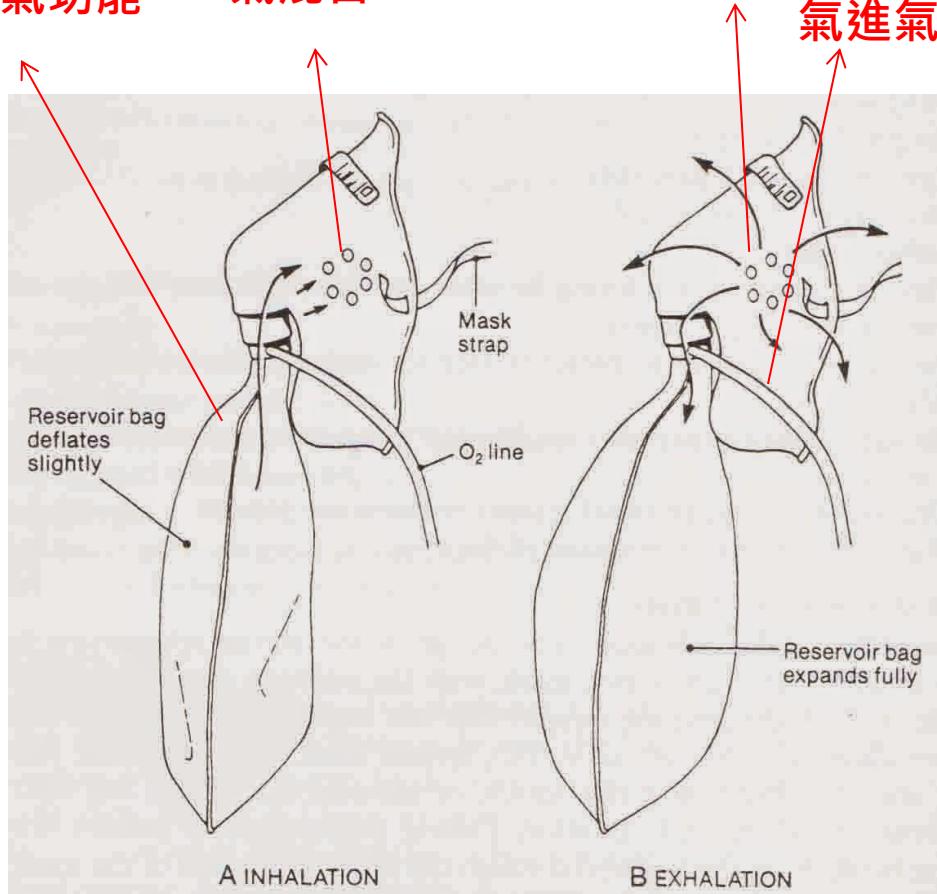
柏努力定理



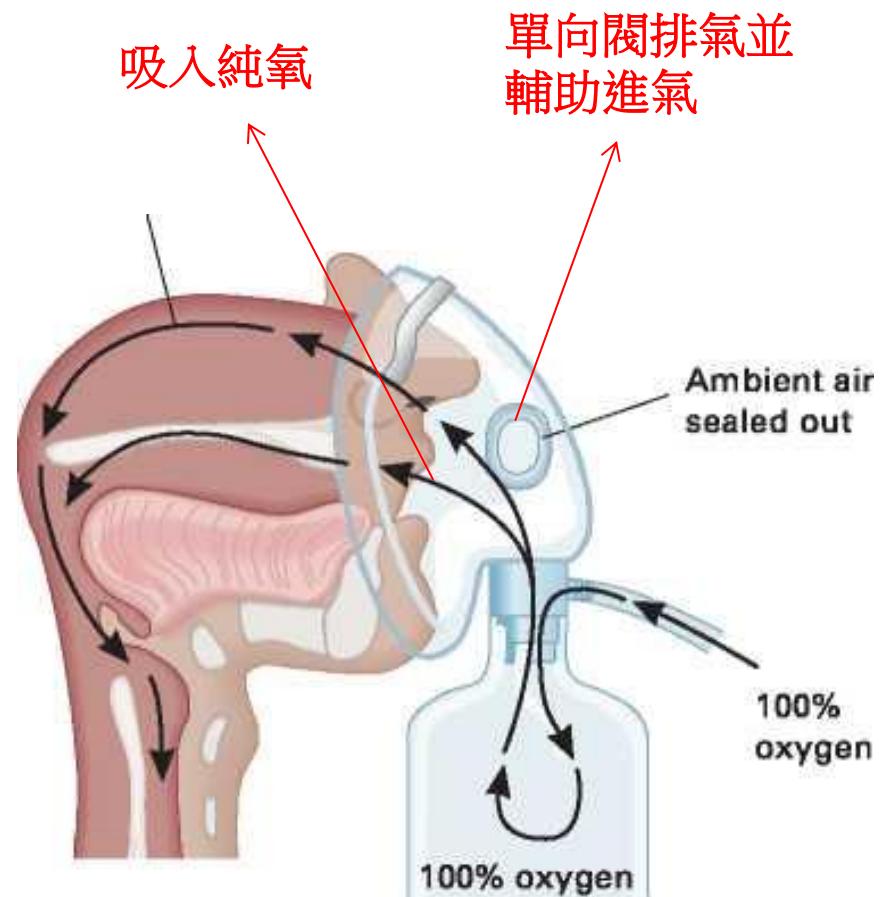
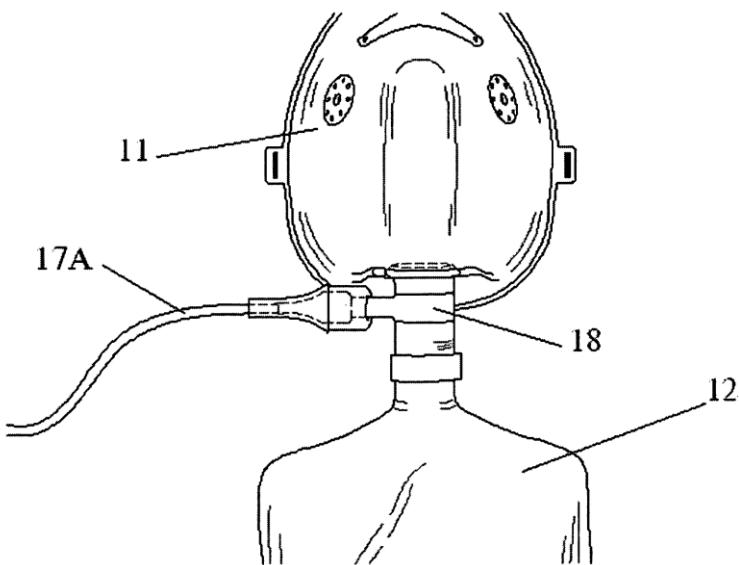
2. 部份再吸入面罩(partial rebreathing mask)： 供應流速 8-15L/min，可以提供35-60%濃度的氧氣。



提供儲氣功能
可吸入空氣混合
1. 排出二
氧化碳
2. 幫助氧氣進氣

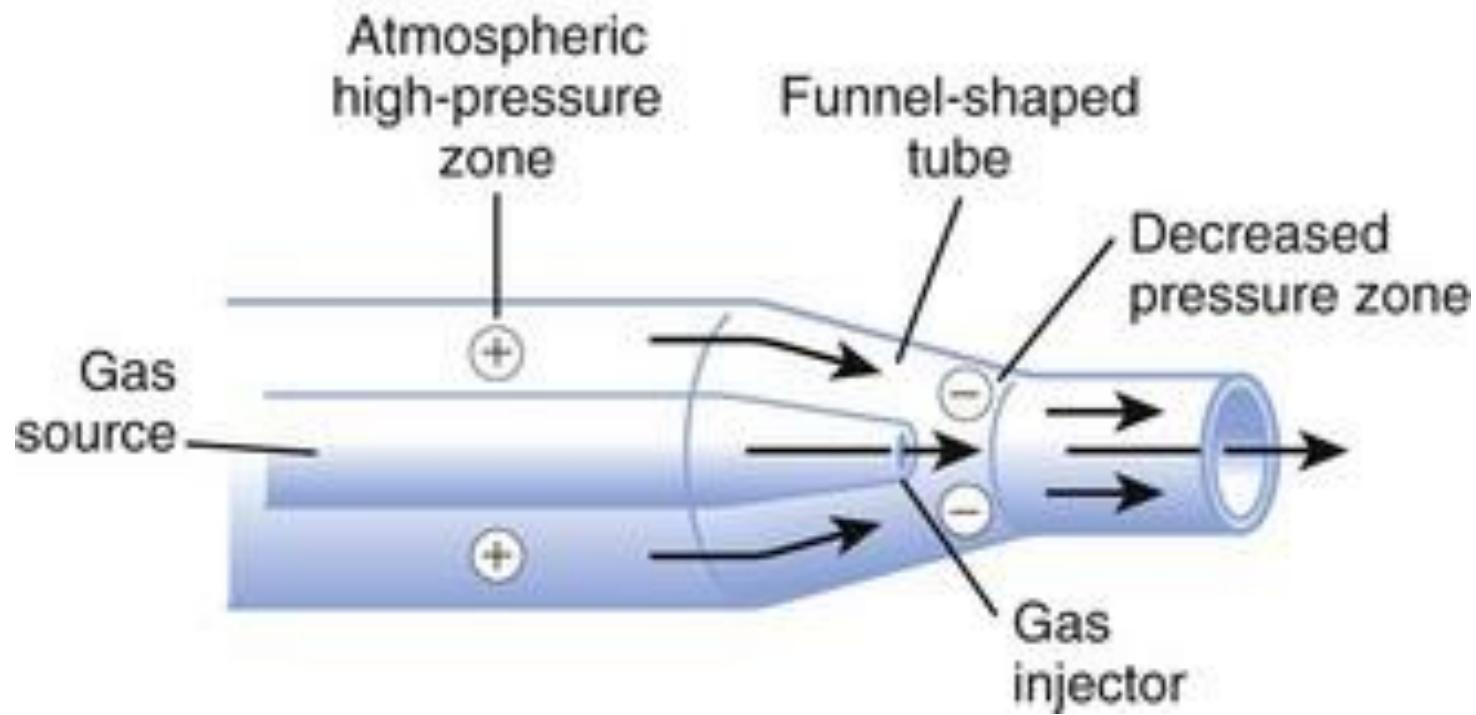


3. 非再吸入性面罩 (non rebreathing mask) :
供應流速 8-15L/min , 可以提供75-100%濃度的
氧氣。

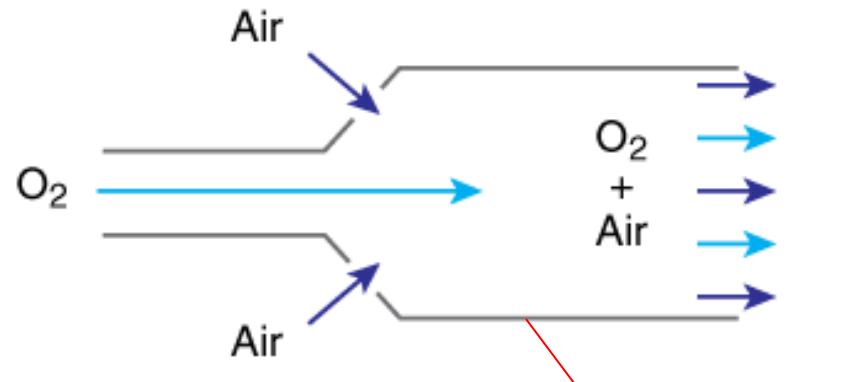
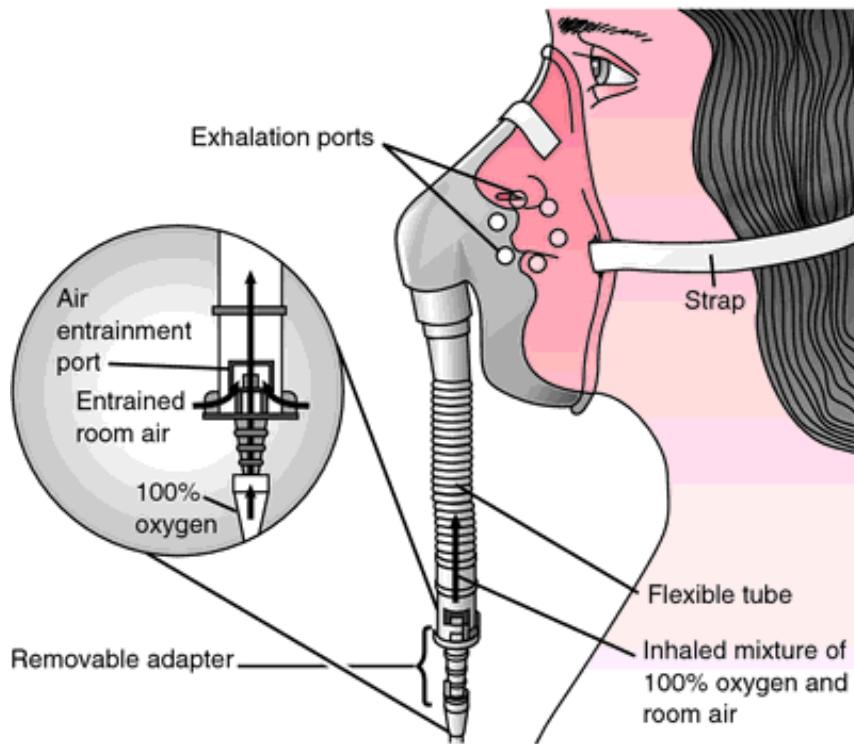


文氏管原理

Venturi principle



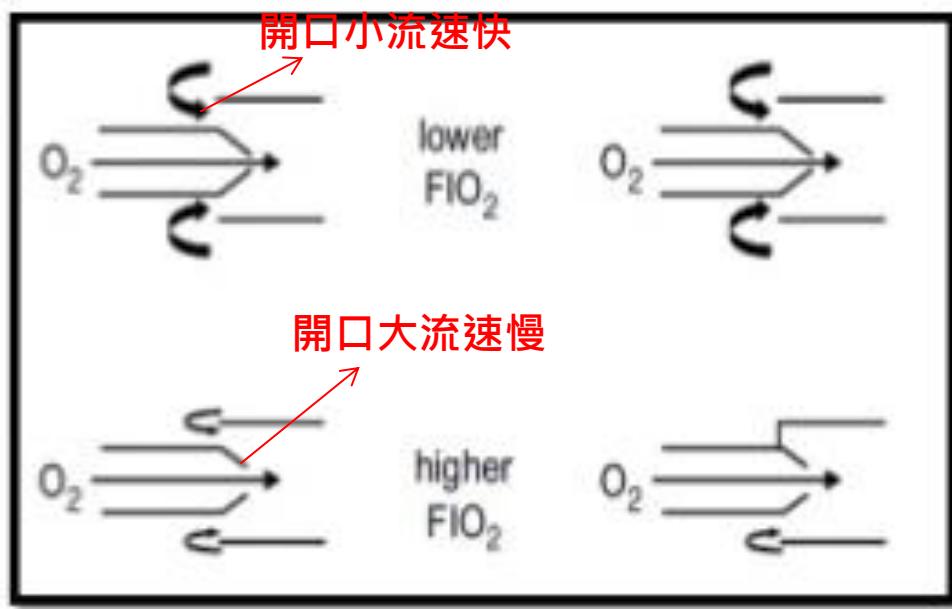
4. 文丘裡面罩 (venturi mask)：應用白努利原理，因供應氧氣的口徑縮小，側邊的空氣藉此混入，可以提供 35-60% 濃度的氧氣。



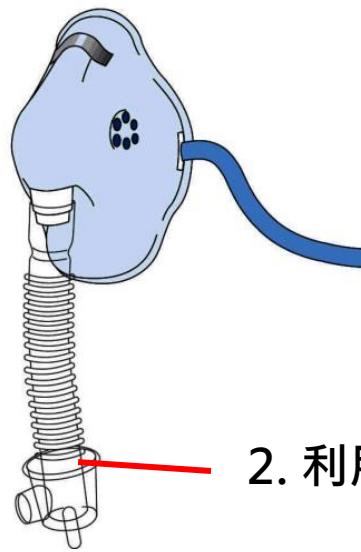
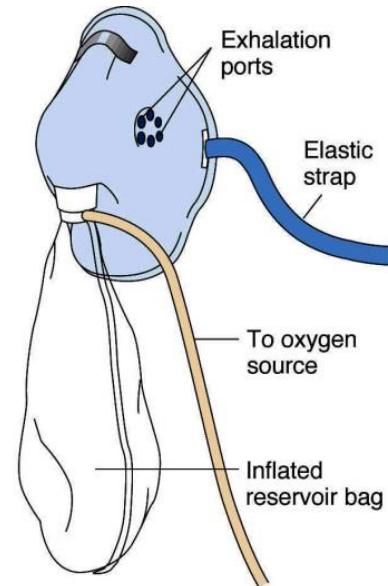
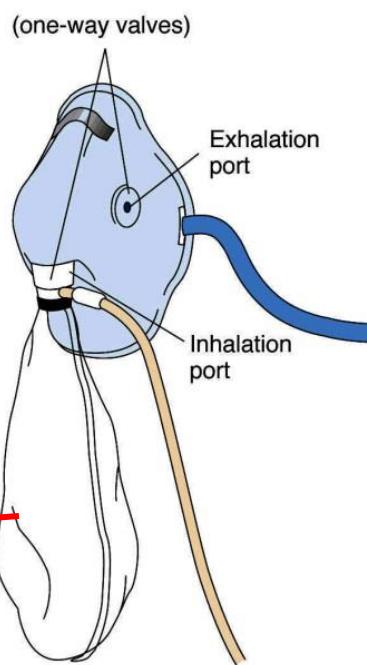
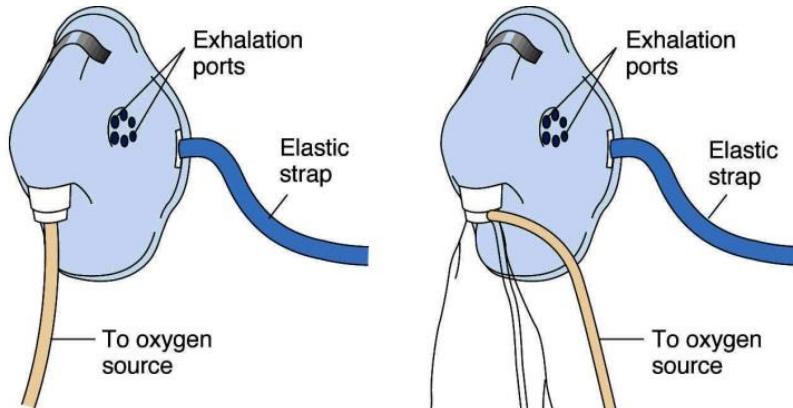
可調式文丘里面罩



增加管徑面積和儲氣量

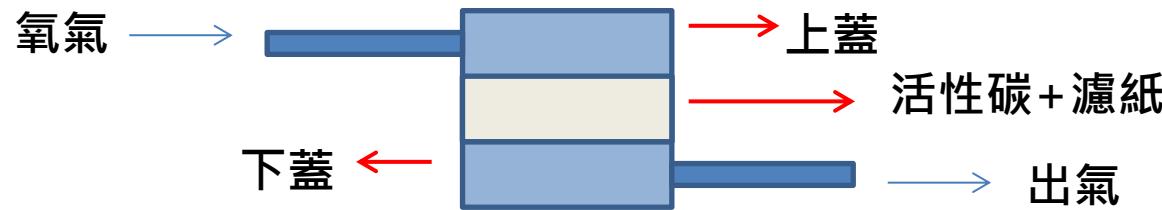


控制氧氣管的氧氣量

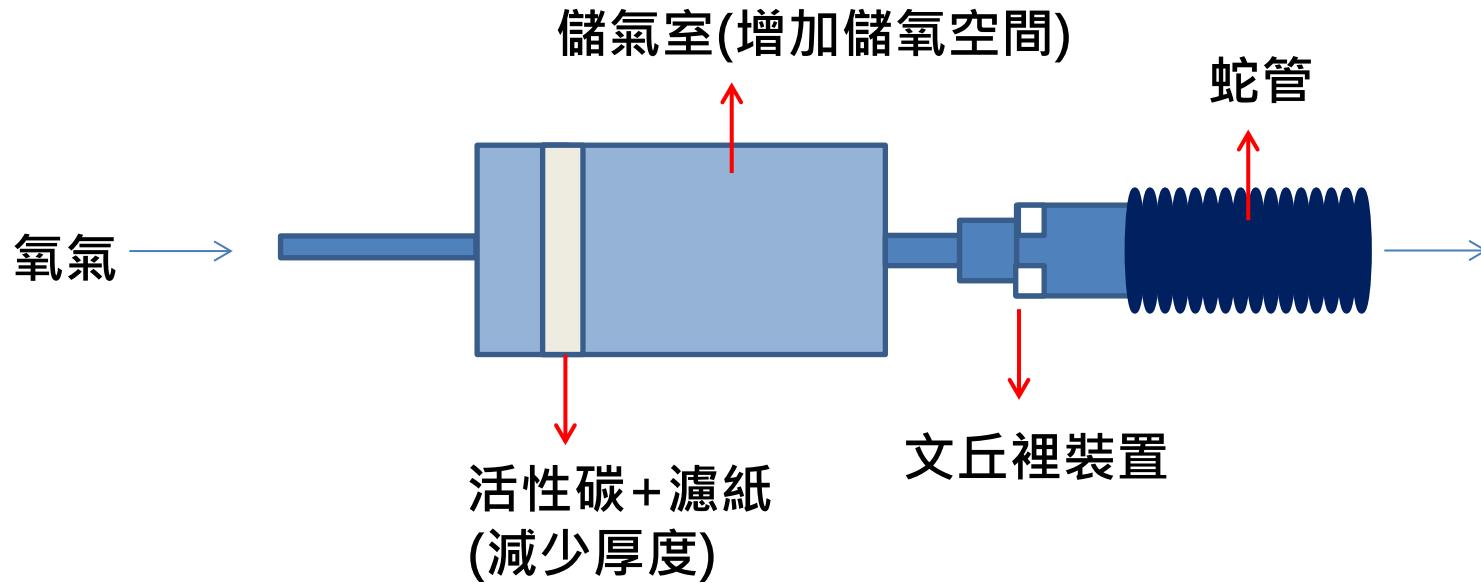


1. 利用儲氣裝置

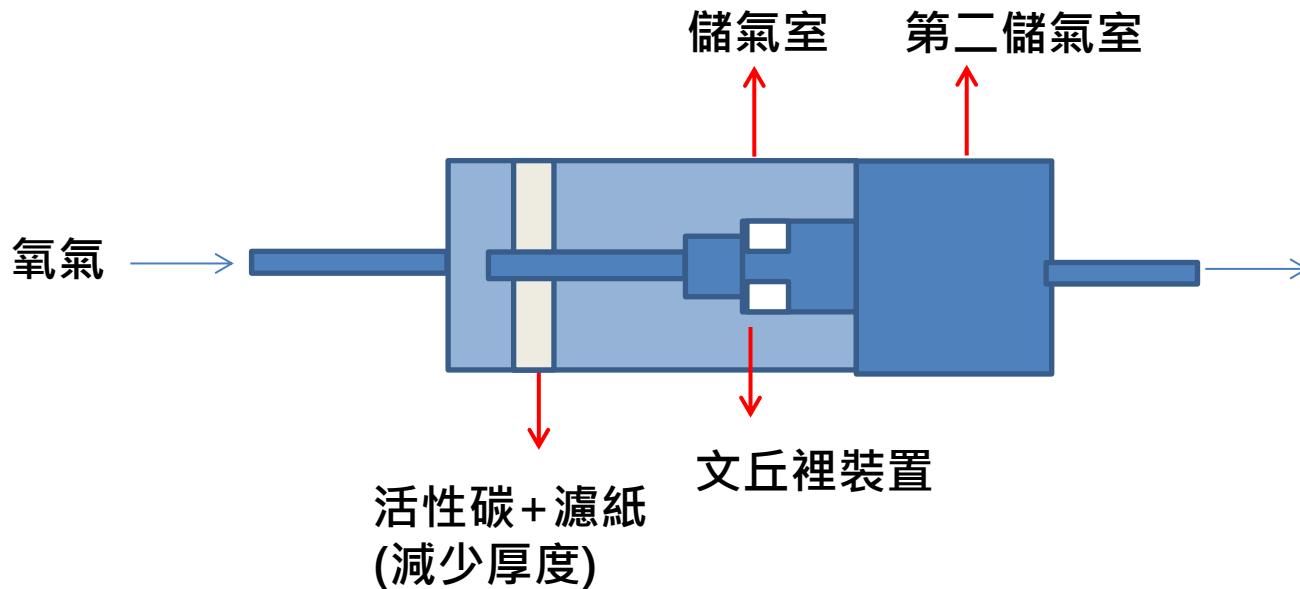
2. 利用柏努力定理



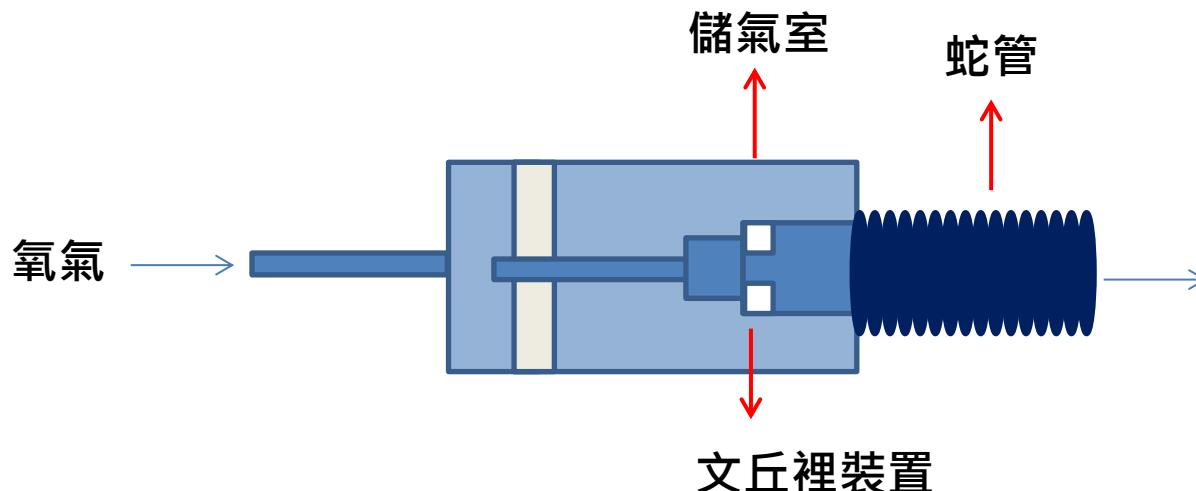
改進計畫 1



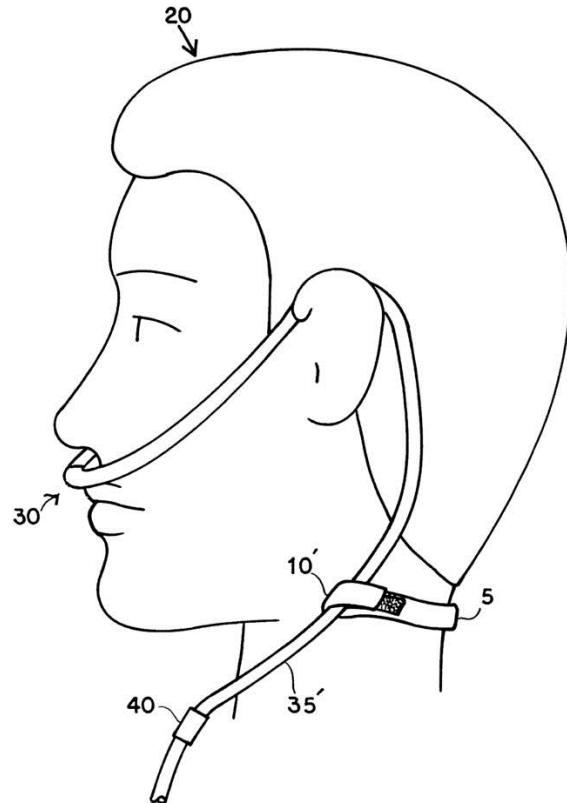
改進計畫 2



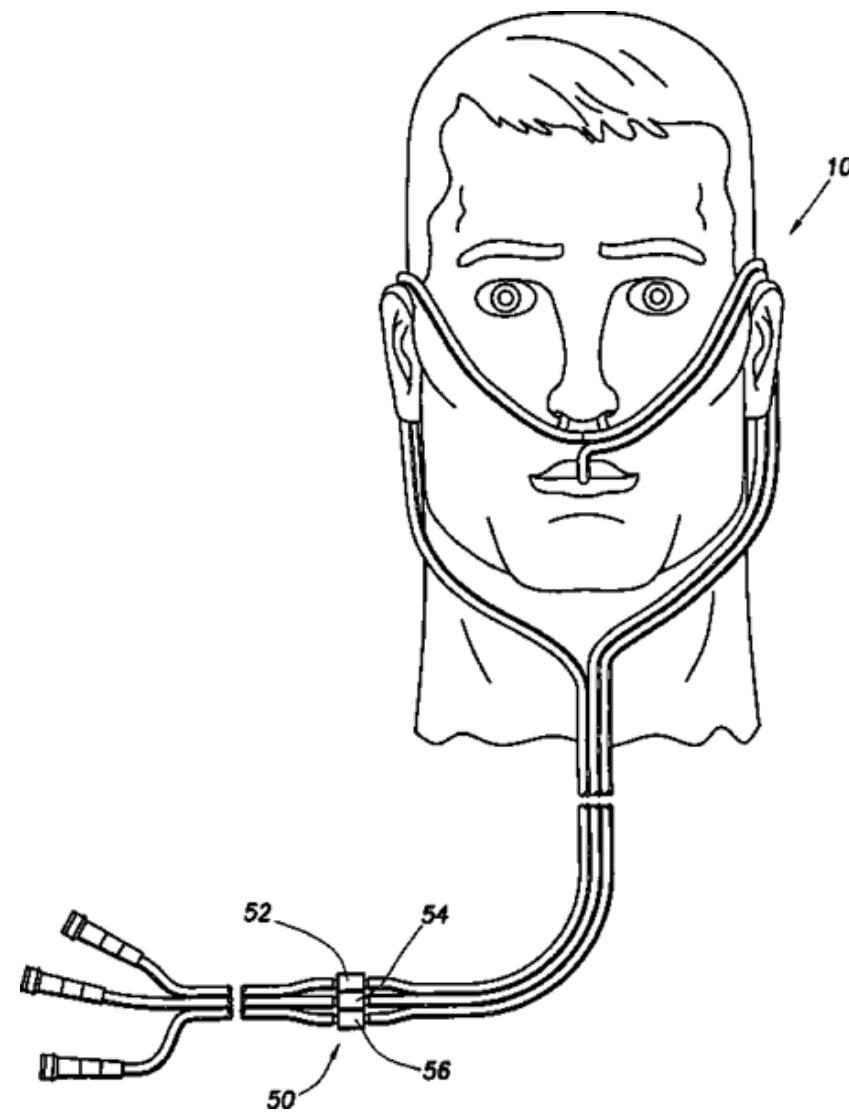
改進計畫 3



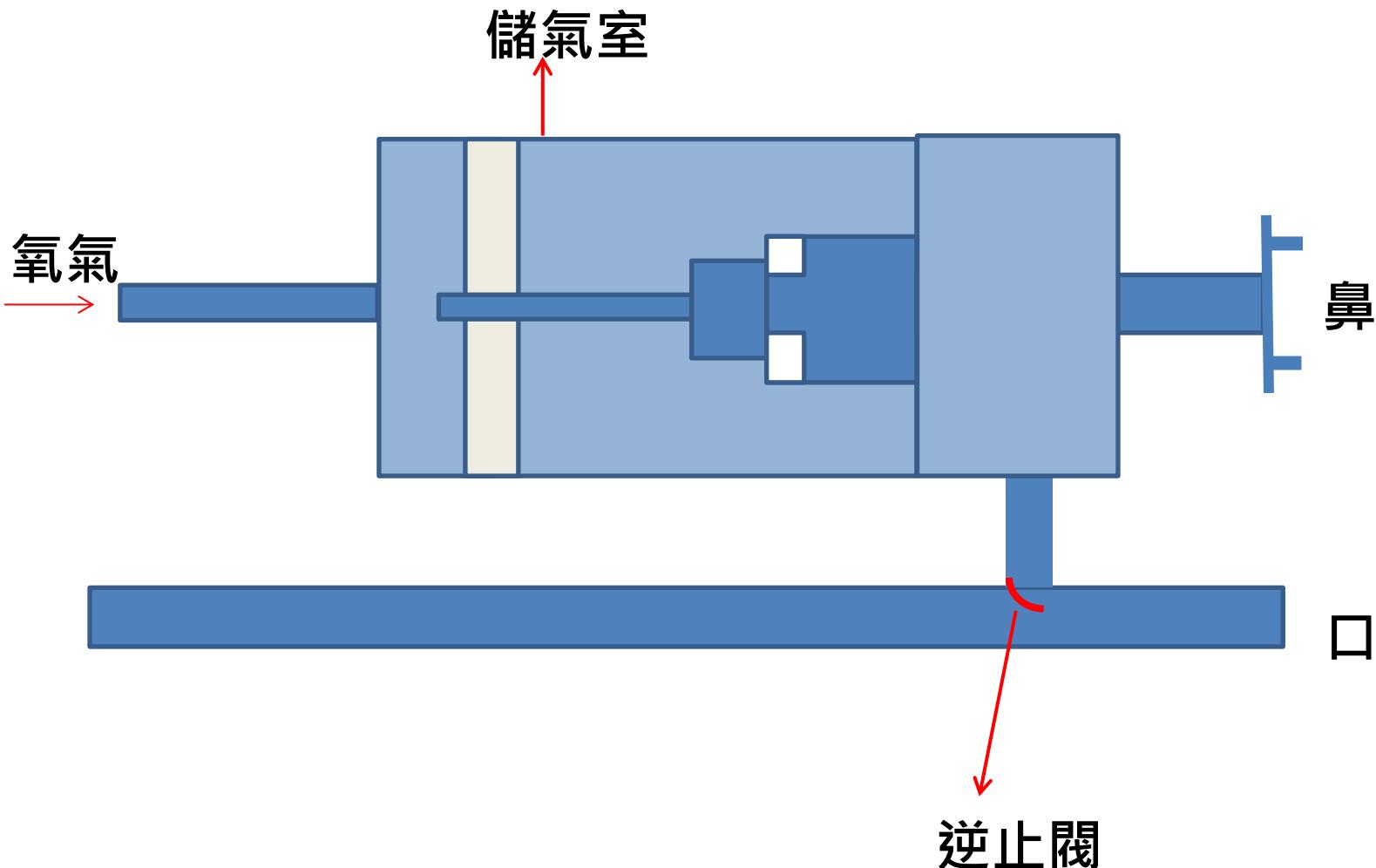
一般稱為 nasal cannula



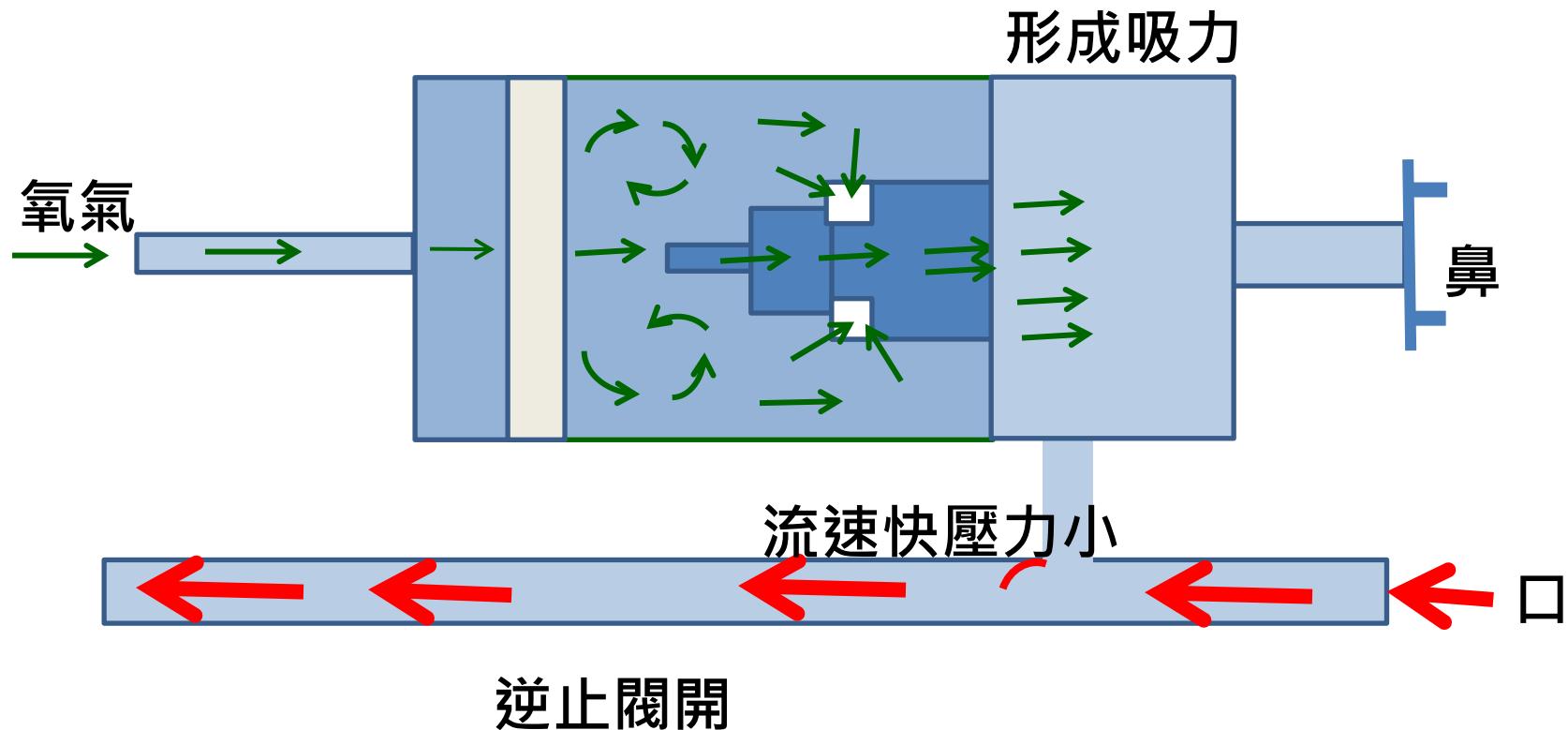
連接到嘴巴的，稱為oral-nasal cannula



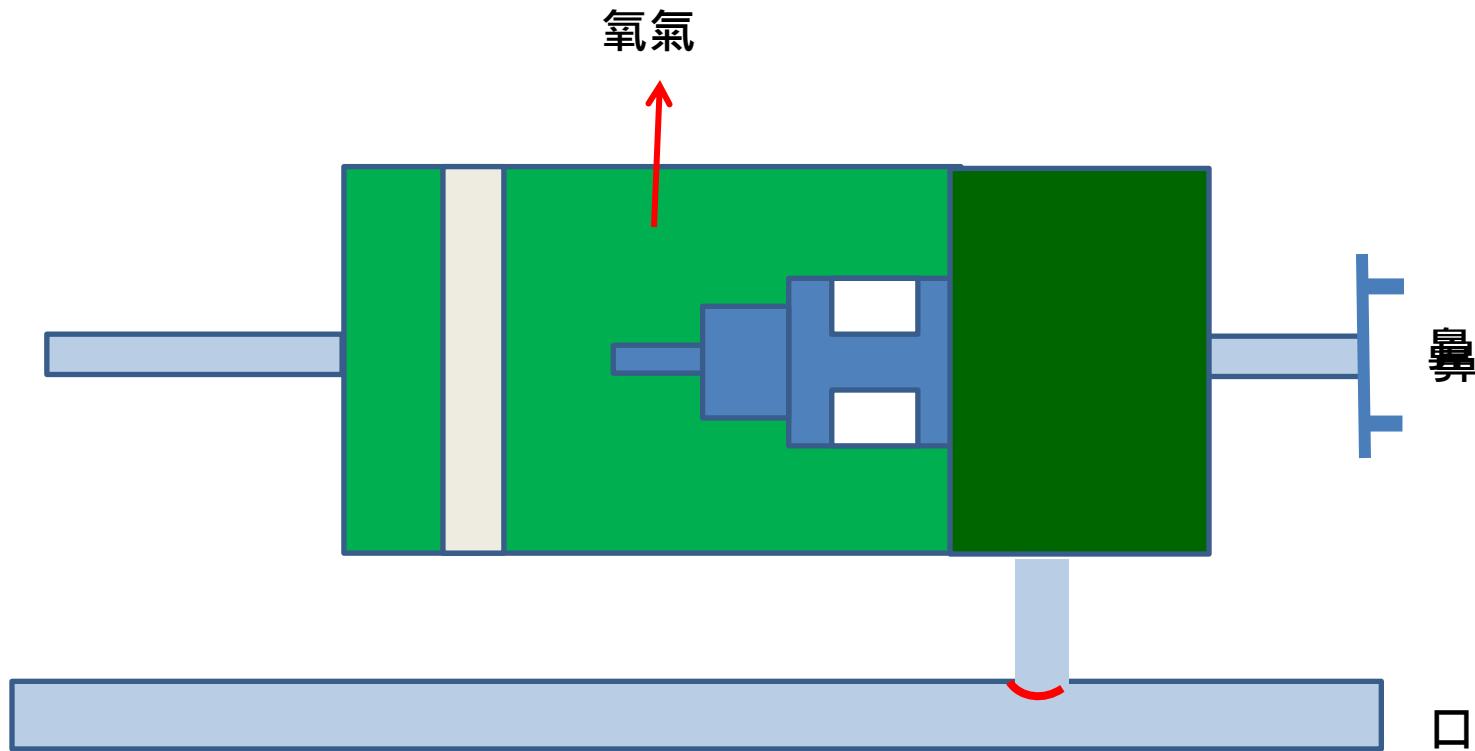
改進計畫 5



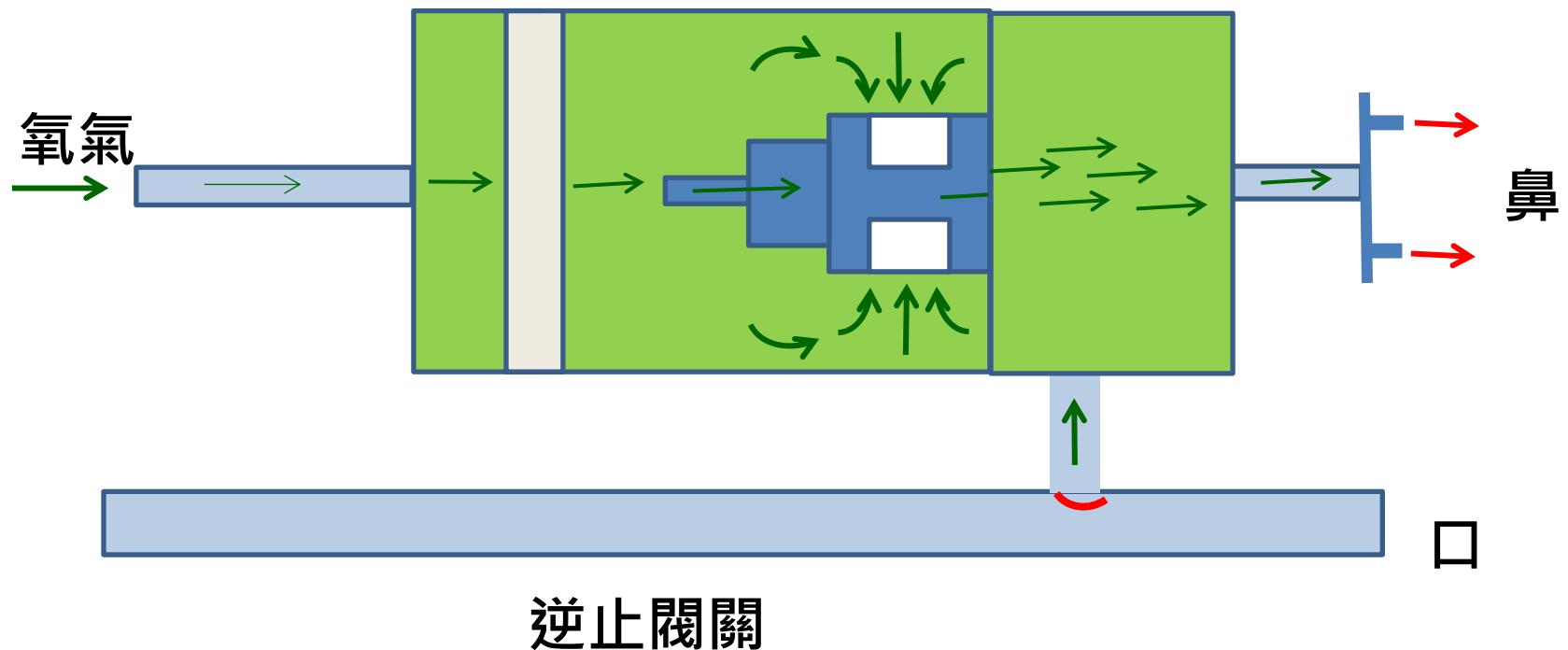
吐氣

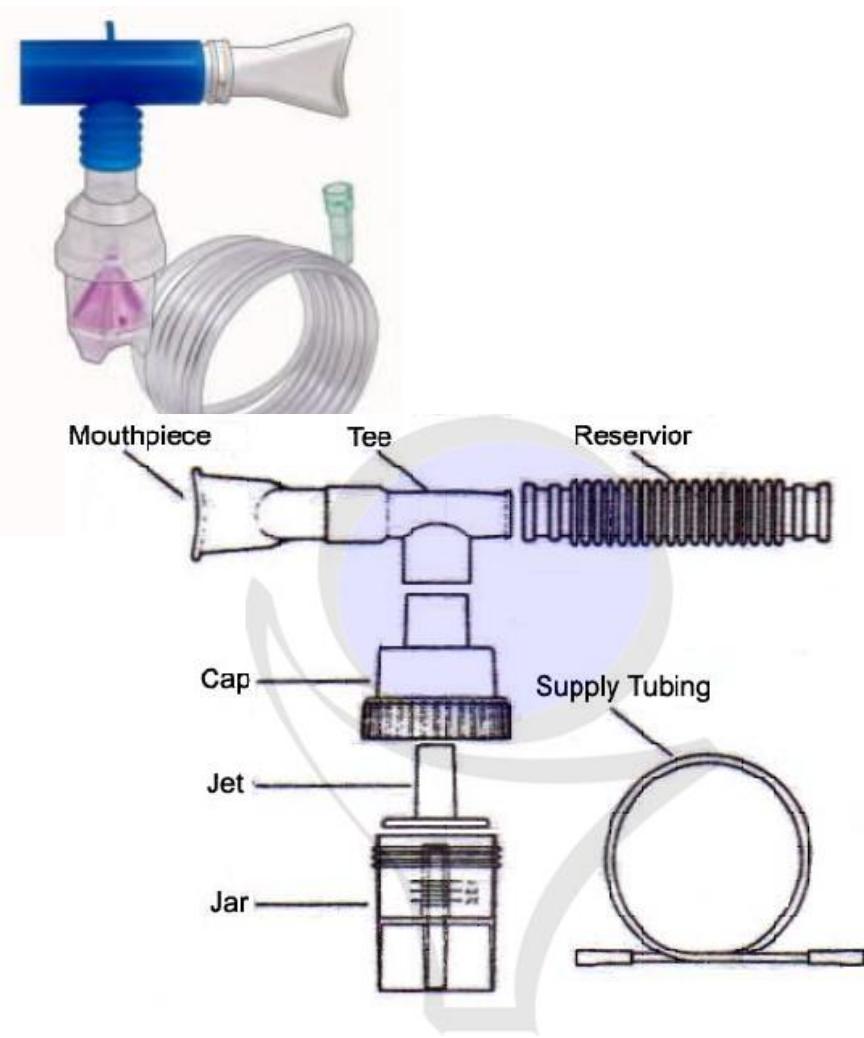


呼吸間隔



吸氣





濕氣治療(humidity)：增加吸入氣體的濕氣量，預防呼吸道黏膜乾燥和減少生理上濕氣不足；如氣泡式 Ohio 潮濕瓶。

霧氣治療(aerosol)：增加吸入氣體的絕對濕度或藥物懸浮粒隨氣體沉澱在呼吸道產生療效；如噴霧瓶和小噴霧器(nebulizer kit)。

以無患子籽仁水粹物製備兼具穩定口腔菌相與抗發炎之人工唾液以預防口腔誤嚥型吸入性肺炎

Preparation of artificial saliva with stable oral bacterial phase and anti-inflammation effects using *Sapindus mukorossi* seed extraction to prevent oral aspiration pneumonia

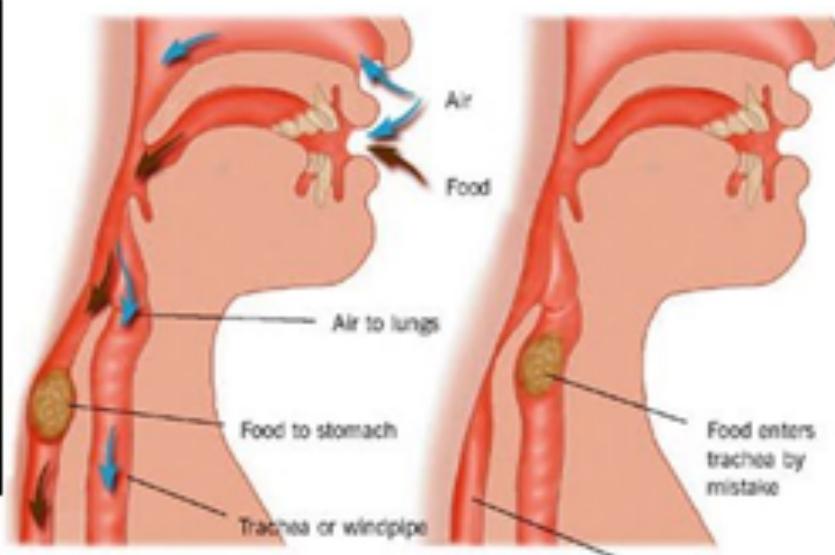
總主持人：黃豪銘 教授

吸入性肺炎 (Aspiration Pneumonitis)

吸入有毒氣體或過敏原，或不小心把食物、嘔吐物等異物吸入肺部而導致的肺部發炎。

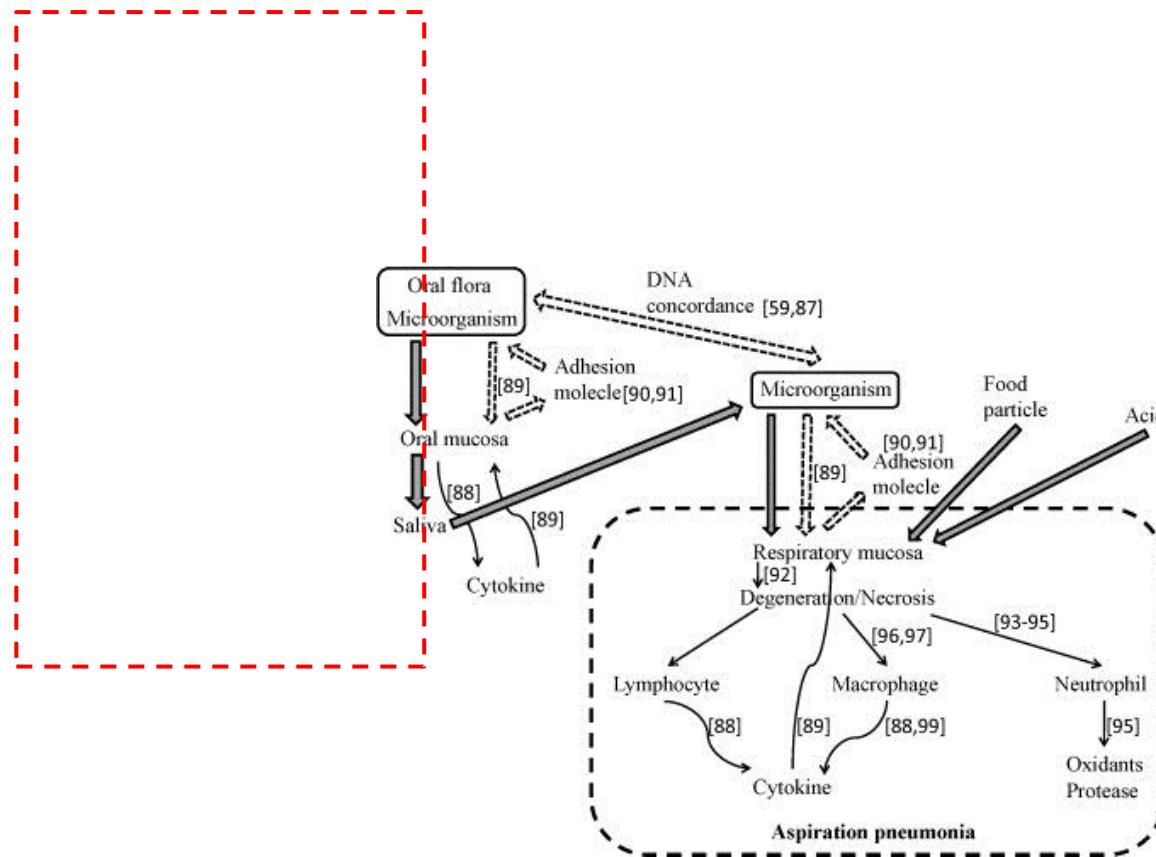
順位	合計					
	ICD-10 國際死因 分類號碼	死亡原因	死亡 人數	每十萬人口 死亡率	標準化 死亡率	
					死亡人數 結構比 %	
1	A00-Y98	所有死亡原因	173,067	733.9	390.8	100.0
2	C00-C97	急性腫瘤	50,161	212.7	117.3	29.0
3	I01-I02.0, I05-I09, I20-I25, I27, I30-I32 心臟疾病 (高血壓性疾病 除外)	心臟疾病 (高血壓性疾病 除外)	20,457	86.7	43.8	11.8
3	J12-J18	肺炎	13,736	58.2	26.4	7.9

圖一：109年國人死因統計表 (來源：衛生福利部)



- 根據台灣「109年國人死因統計結果」，肺炎在十大死因中排名第3。
- 台灣全民健保資料統計，吸入性肺炎平均死亡率高達近5成。
- 38.7%的吸入性肺炎患者有吞嚥障礙的困擾。

Aspiration pneumonia pathogenesis



(Kuyama et al., 2010)



NIH Public Access

Author Manuscript

Oral Dis. Author manuscript; available in PMC 2008 February 28.

Published in final edited form as:

Oral Dis. 2007 November ; 13(6): 508–512.

Oral biofilms, periodontitis, and pulmonary infections

S Paju^{1,2} and FA Scannapieco³

¹*Institute of Dentistry, University of Helsinki, Helsinki, Finland* ²*Department of Oral and Maxillofacial Diseases, Helsinki University Central Hospital, Helsinki, Finland* ³*Department of Oral Biology, School of Dental Medicine, University at Buffalo, State University of New York, Buffalo, NY, USA*

Abstract

Bacteria from the oral biofilms may be aspirated into the respiratory tract to influence the initiation and progression of systemic infectious conditions such as pneumonia. Oral bacteria, poor oral hygiene, and periodontitis seem to influence the incidence of pulmonary infections, especially

nosocomial pneumonia episodes in high-risk subjects. Improved oral hygiene has been shown to reduce the occurrence of nosocomial pneumonia, both in mechanically-ventilated hospital patients and non-ventilated nursing home residents. It appears that oral colonization by potential respiratory pathogens, possibly fostered by periodontitis, and possibly by bacteria specific to the oral cavity or to periodontal diseases contribute to pulmonary infections. Thus, oral hygiene will assume an even more important role in the care of high-risk subjects – patients in the hospital intensive care and the elderly. The present paper critically reviews the recent literature on the effect of oral biofilms and periodontitis on pneumonia.

The Oral Microbiome and Lung Diseases

Chan Y. Pu¹ · Mukund Seshadri² · Sunita Manuballa² · Sai Yendamuri^{3,4}

88

Table 1 Summary of studies evaluating oral microbiota alone or in comparison with the lung microbiota in healthy and diseased lungs

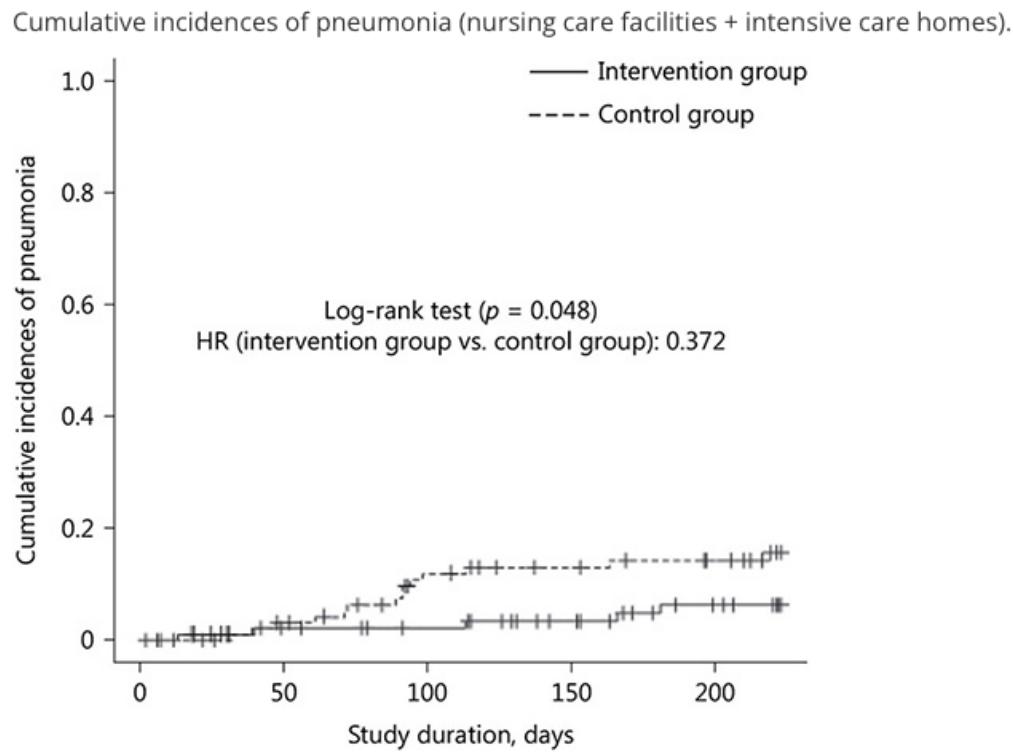
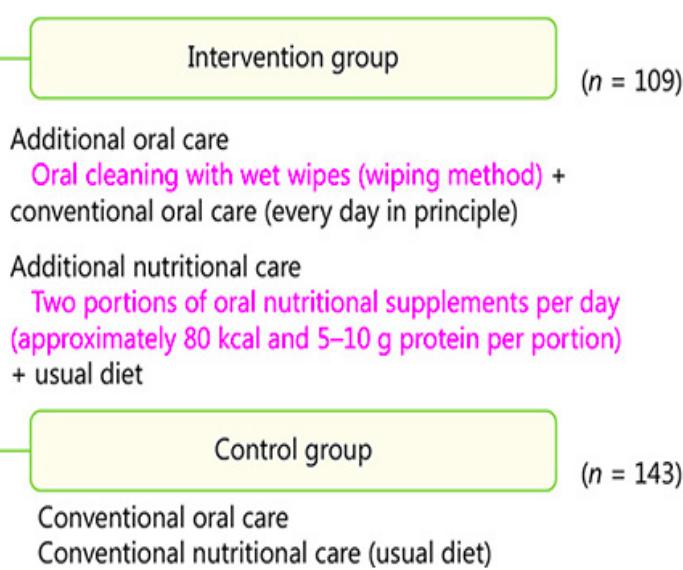
Study	Patient type and number	Sample method	Sequence method	Major findings
Healthy subjects				
Charlson 2011 (17)	6 healthy subjects	Oral wash and oropharyngeal swab Serial BAL and protected brush	16s rRNA gene sequencing	Oral and lung microbiome were homogenous
Bassis 2015 (18)	28 healthy subjects	Oral wash BAL, nasal swab, gastric aspirate	16s rRNA gene sequencing	Lung microbiota was significantly different from the communities in the mouth, nose, and stomach. Lungs exhibited selective elimination of <i>Prevotella</i> bacteria derived from the upper airways.
HIV				
Beck 2015 (8)	86 healthy subjects 18 treatment naïve HIV-infected patients 38 HIV-infected patients on antiretroviral therapy	Oral wash BAL	16s rRNA gene sequencing	Microbiota in oral washes was different between HIV-infected and HIV-uninfected patients but BAL microbiota was not significantly different.
Morris 2013 (11)	HIV patients 45 nonsmoker 19 smoker	Oral wash BAL	16s rDNA gene sequencing	Microbiota of oral cavity and lungs were similar with some distinct bacterial overrepresentation in the lung Oral microbiota of smoker and nonsmokers were different but the difference was not present in the lungs.
Pneumonia				
Fourrier 1998 (24)	57 ICU patients	Dental plaque sample Tracheal aspirate	Bacterial culture	As duration of ICU stay increased, likelihood of dental plaque colonization increased which was predictive of subsequent nosocomial infection
El-Sohly 2004 (36)	14 ICU patients who developed HAP	Dental plaque sample Protected BAL	Pulsed-field gel electrophoresis	The genetic match between bacteria isolated from dental plaque and BAL suggested that aerobic respiratory bacterial colonizing of dental plaque was a potential reservoir for HAP.
Heo 2008 (35)	100 mechanically ventilated ICU patients	Dental plaque sample Tracheal aspirate BAL (only in 30 patients with VAP)	Pulsed-field gel electrophoresis and multilocus sequencing	Majority of oral respiratory bacterial isolates were genetically indistinguishable from tracheal and BAL isolates.
Bahrani 2007 (38)	16 mechanically ventilated ICU patients with VAP	Dorsal surface of tongue sample BAL	16s rRNA gene sequencing	88% of patients with VAP had overlapping bacterial in oral cavity and lungs. Dorsal surface of tongue was a potential reservoir of bacteria for VAP.
Cystic fibrosis				
Rivas 2015 (44)	CF patients 5 patients with chronic colonization by <i>P. aeruginosa</i> and 5 non-chronic colonization patients	Saliva and periodontal pocket samples Sputum	Pulsed-field gel electrophoresis	The same bacteria close was present in saliva, lung (sputum), and subgingival plaques suggesting an ascending and descending passage of bacteria between the oral cavity and lungs.
Komiyama 1985 (45)	31 CF patients	Samples from dorsum of the tongue, buccal mucosa, dental plaques and saliva Sputum	Culture and sensitivity	45% of patients yielded <i>P. aeruginosa</i> from various oral ecological sites and saliva. Dorsum of the tongue had the highest yield of <i>P. aeruginosa</i> .
COPD				
Pragman 2019 (67)	COPD patients 11 frequent exacerbator (FE) 11 infrequent exacerbator (IE)	Oral wash Sputum	16s rRNA gene sequencing	Oral and sputum microbiota were less diverse in FE than IE.
Liu 2017 (68)	4 patients with AECOPD	Oropharyngeal sample Sputum	16s rRNA gene sequencing	Oropharyngeal and sputum samples had similar microbiota composition but oropharyngeal samples had higher bacterial alpha diversity
Lung cancer				
Yu 2016 (19)	Patients with lung cancer	Surgically resected lung tissue consisting of 31 malignant and 165 non-malignant (distant from primary lung tumor) samples Corresponding samples from oral cavity, nasal cavity, gut, skin and vagina	16s rRNA gene sequencing	Lung microbiota is significantly different from the communities in the mouth, nose, stool, skin and vagina.
Yan 2015 (71)	10 patients with lung squamous cell cancer 10 patients with lung adenocarcinoma 10 healthy control subjects	Saliva	16s rRNA gene sequencing	Levels salivary of <i>Capnocytophaga</i> and <i>Veillonella</i> were significantly higher in patients with squamous cell cancer and adenocarcinoma suggesting a potential use as biomarker.
Yang 2018 (72)	75 non-smoking female with lung cancer 172 matched healthy control subjects	Saliva	16s rRNA gene sequencing	Compared with healthy subjects, patients with lung cancer had decreased microbial diversity and occurrence of dysbiosis in salivary microbiota
Zhang 2019 (73)	39 patients with NSCLC 20 healthy control subjects	Saliva	16s rRNA gene sequencing	Genera <i>Veillonella</i> and <i>Streptococcus</i> were strongly increased in NSCLC salivary microbiota compared to controls

BAL, bronchoalveolar lavage; CF, cystic fibrosis; HAP, hospital-acquired pneumonia; ICU, intensive care unit; NSCLC, non-small cell lung cancer; VAP, ventilator-associated pneumonia

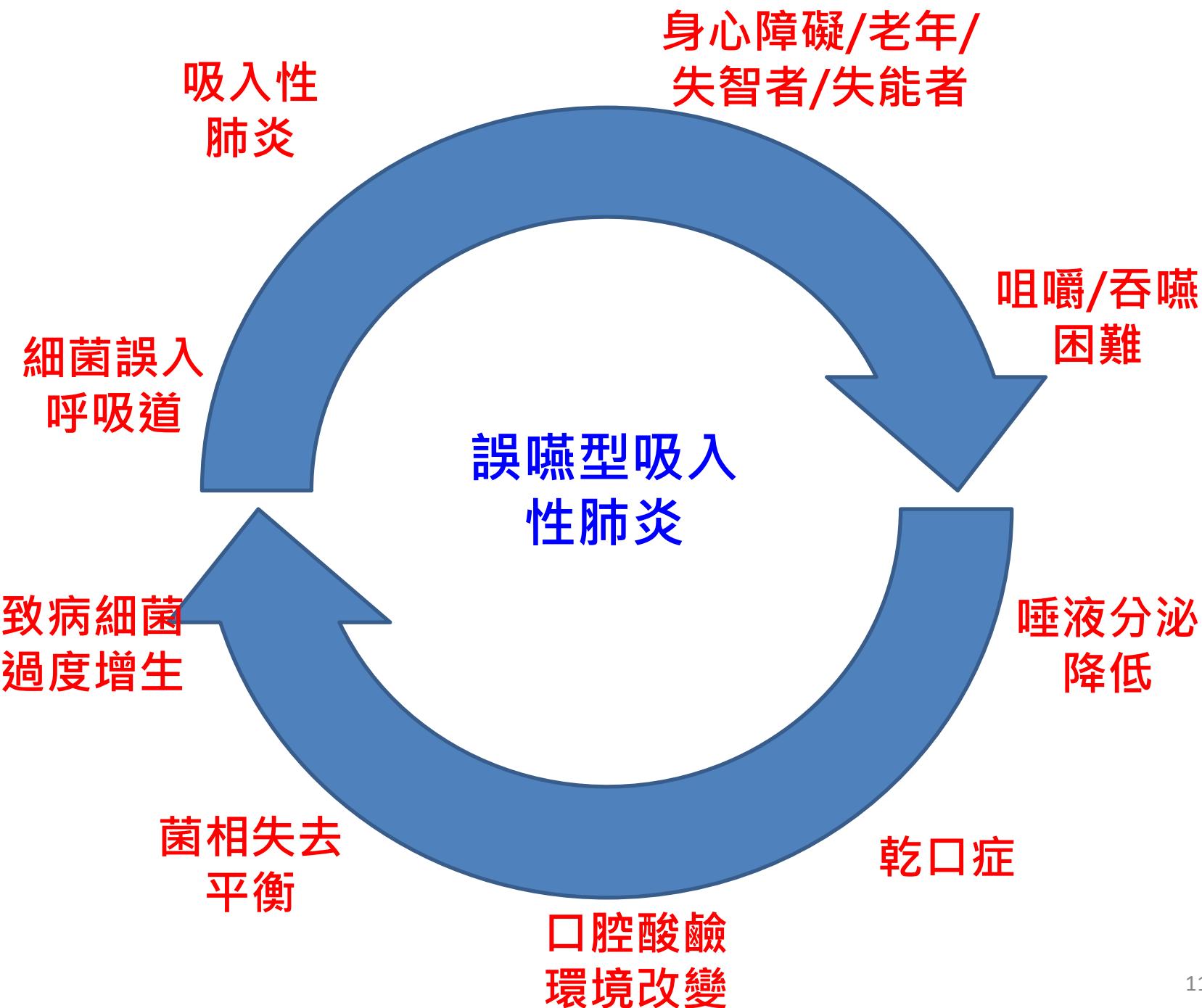
Enhanced oral hygiene reduces the incidence of aspiration pneumonia

Study design.

Subjects



(Higashiguchi et al., 2017)



現行產品分析: 人工唾液/拭紙



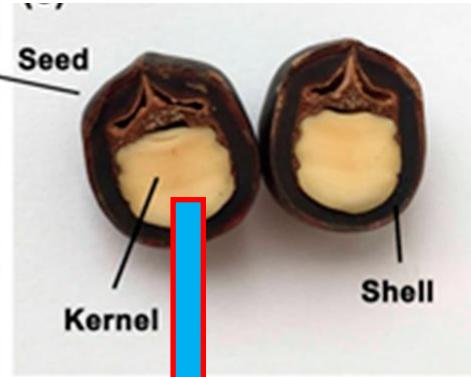
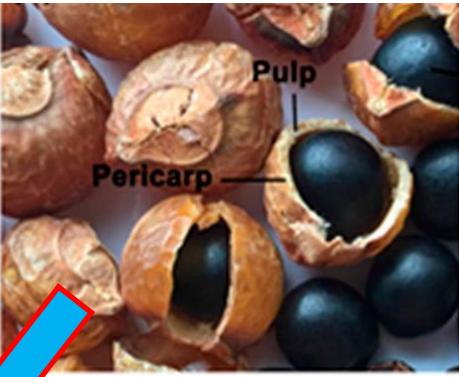
口腔内の
食べかす等の除去

歯と歯茎、口腔粘膜の
マッサージ

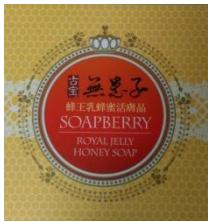
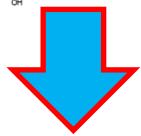
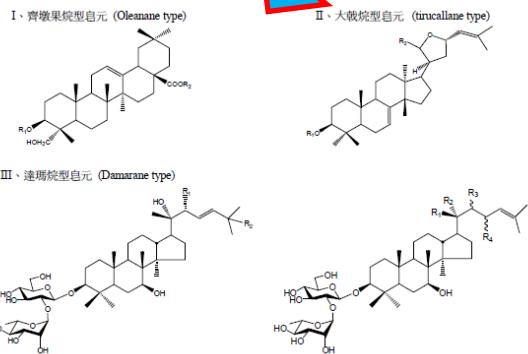
舌の汚れの
清拭・清浄



無患子(菩提子)- 龍眼科 木本植物

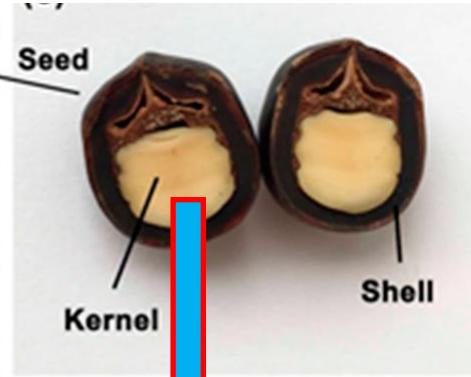
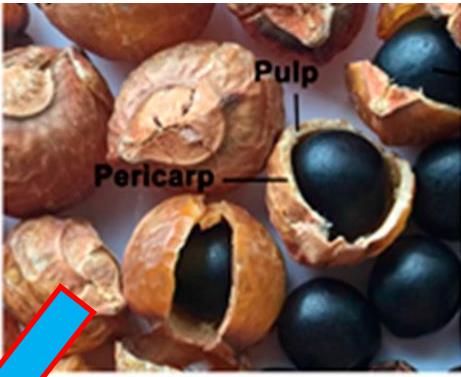


種子皮與肉:
含皂甘，為
目前**所有**市
售無患子商
品的添加成
分

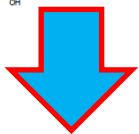
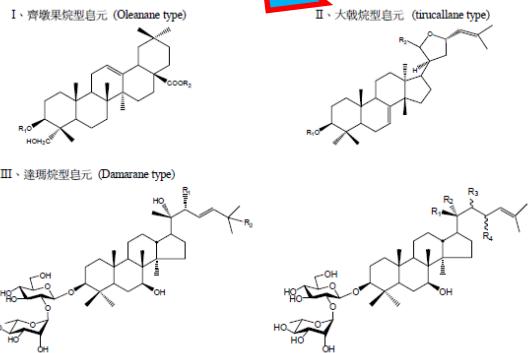


種子核仁: 含
30%種子油，
目前評估作為
生質材油，或
做為**肥料**，或
以**廢棄物**處理

無患子(菩提子)- 龍眼科 木本植物



種子皮與肉:
含皂甘，為
目前**所有**市
售無患子商
品的添加成
分



種子核仁: 含
30%種子油，
目前評估作為
生質材油，或
做為**肥料**，或
以**廢棄物**處理

功效有感

起泡洗潔

濟方

普

附方

新

牙齒腫痛。

肥珠子一兩。大黃香附各一兩。

泥固煅研。日用擦牙。

食辟惡。

去口臭。

時珍。

子中仁氣味辛平無毒。

主治燒之。辟邪惡氣。

器燶。

燶。

藏器。

燶。

燶。

燶。

燶。

燶。

及點甚良。

集簡方。

泡湯洗頭。良。

事。

多能鄙事。

事。

事。

事。

多能鄙事。

事。

事。

事。

事。

事。

及點甚良。

事。

事。

事。

事。

事。

本草綱目 卷三十五



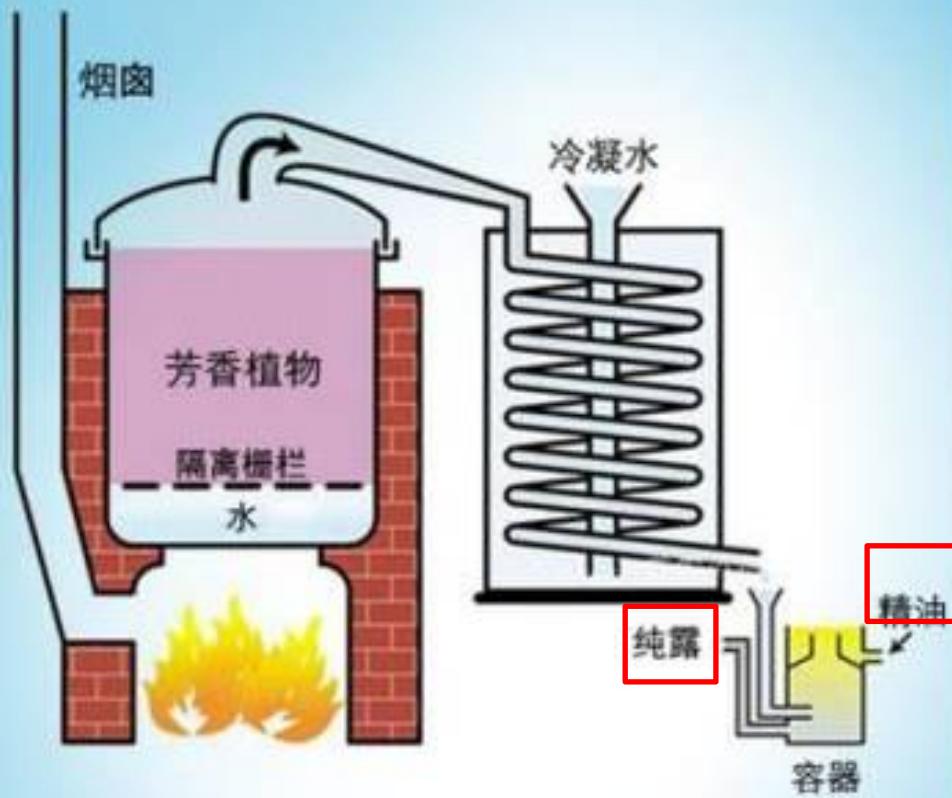
本草綱目

明李時珍著
黃山書社

無患子籽仁水露製備

因含有微量精油分子
滲透力 = 普通爽肤水 × 70倍

纯露是指精油在蒸馏萃取过程中留下来的水，是精油的一种副产品，
是在提炼精油过程中分离出来的一
种100%饱和的纯露，成份天然纯净。



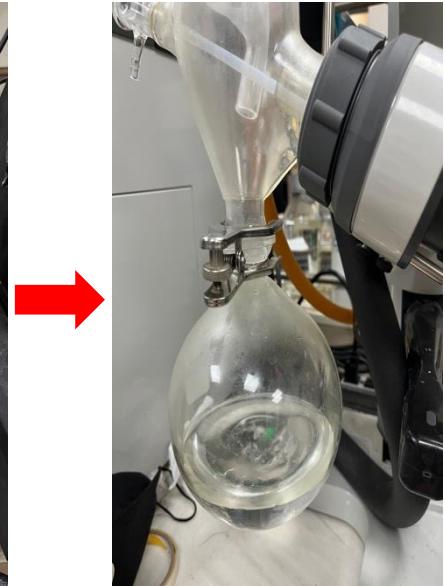
無患子純露

Sapindus mukorossi hydrosol (SMH)

純露是萃取精油的過程中產生的副產物。

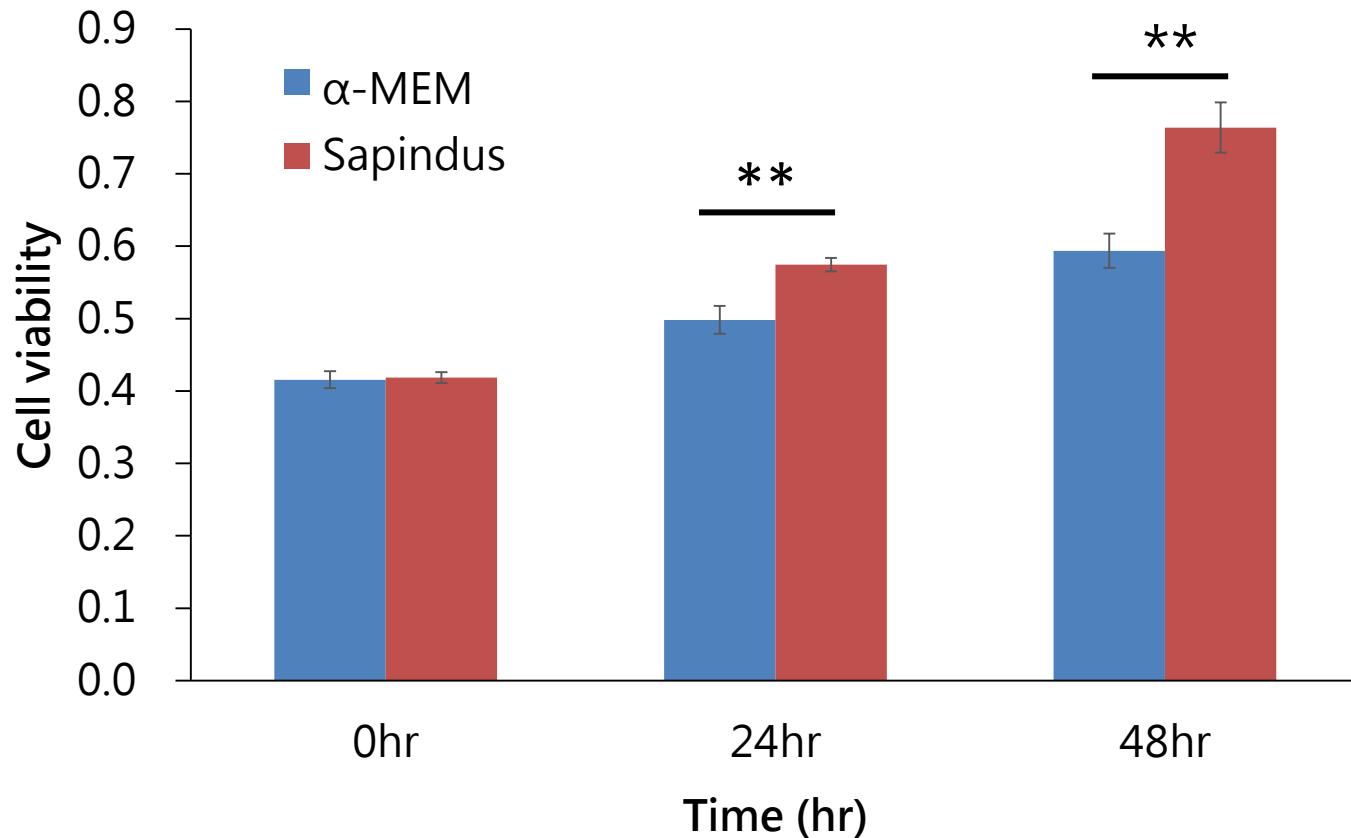


+
水



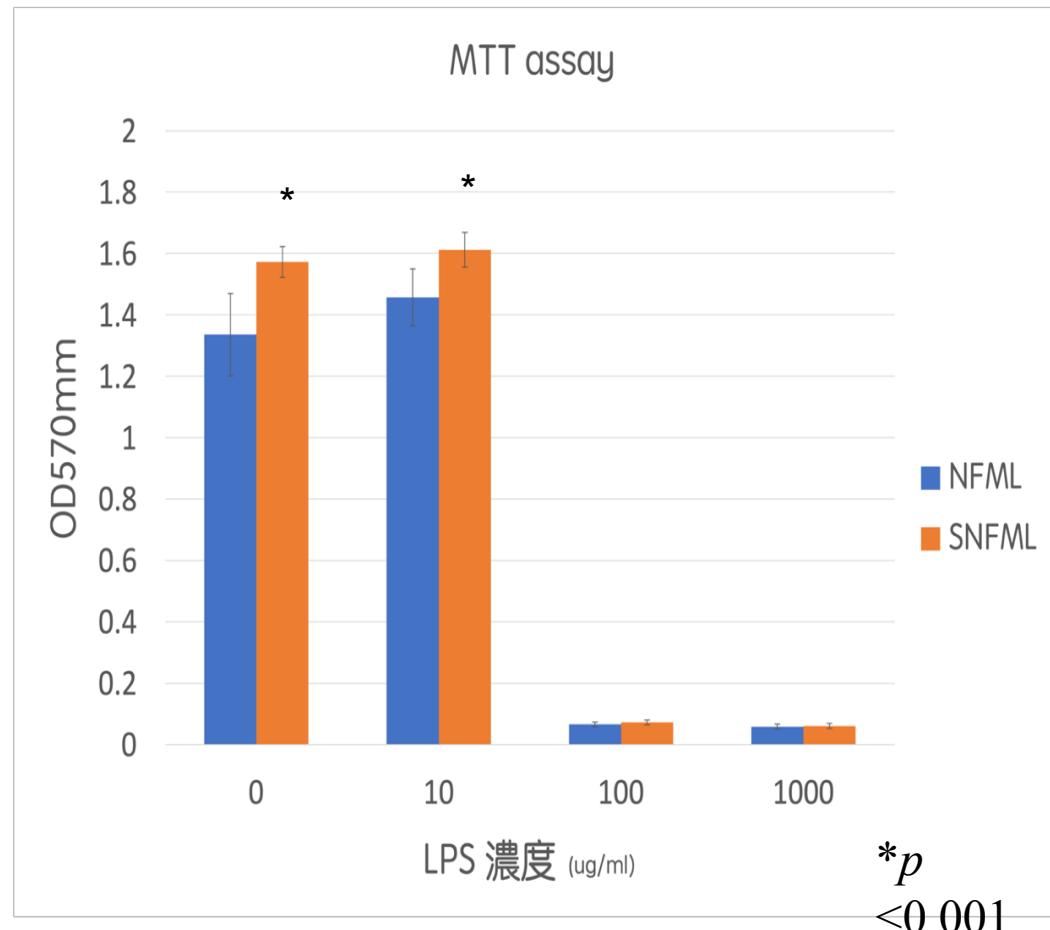
前導實驗 1

無患子籽仁水萃物有助於肺臟細胞的活性



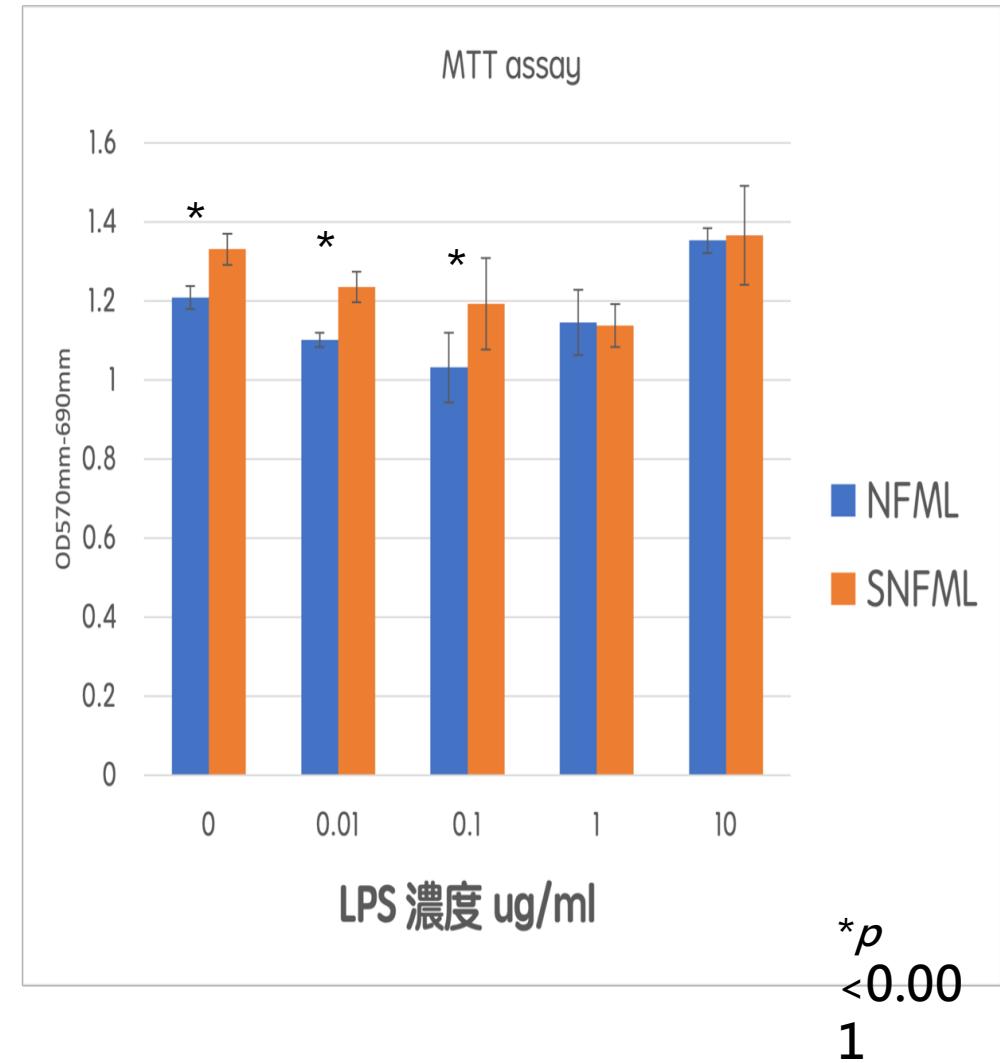
Calu-3細胞暴露於LPS之耐受濃度

- 100與1000 ug/ml LPS 細胞暴露過量死亡。
- 10 ug/ml LPS 細胞活性不減反增。



無患子純露對暴露於LPS中Calu-3細胞之影響

無患子純露
發揮有效抑制之LPS作用濃度
約小於1 ug/ml。



前導實驗 2 無患子籽仁水粹物有助於抑制牙周病致病菌



圖三：對照組及試驗物質與肺炎鏈球菌作用
24 小時後之結果。



圖四：對照組及試驗物質與伴放線聚集桿菌
作用 24 小時後之結果。



圖五：對照組及試驗物質與牙齦卟啉單胞菌
作用 24 小時後之結果。

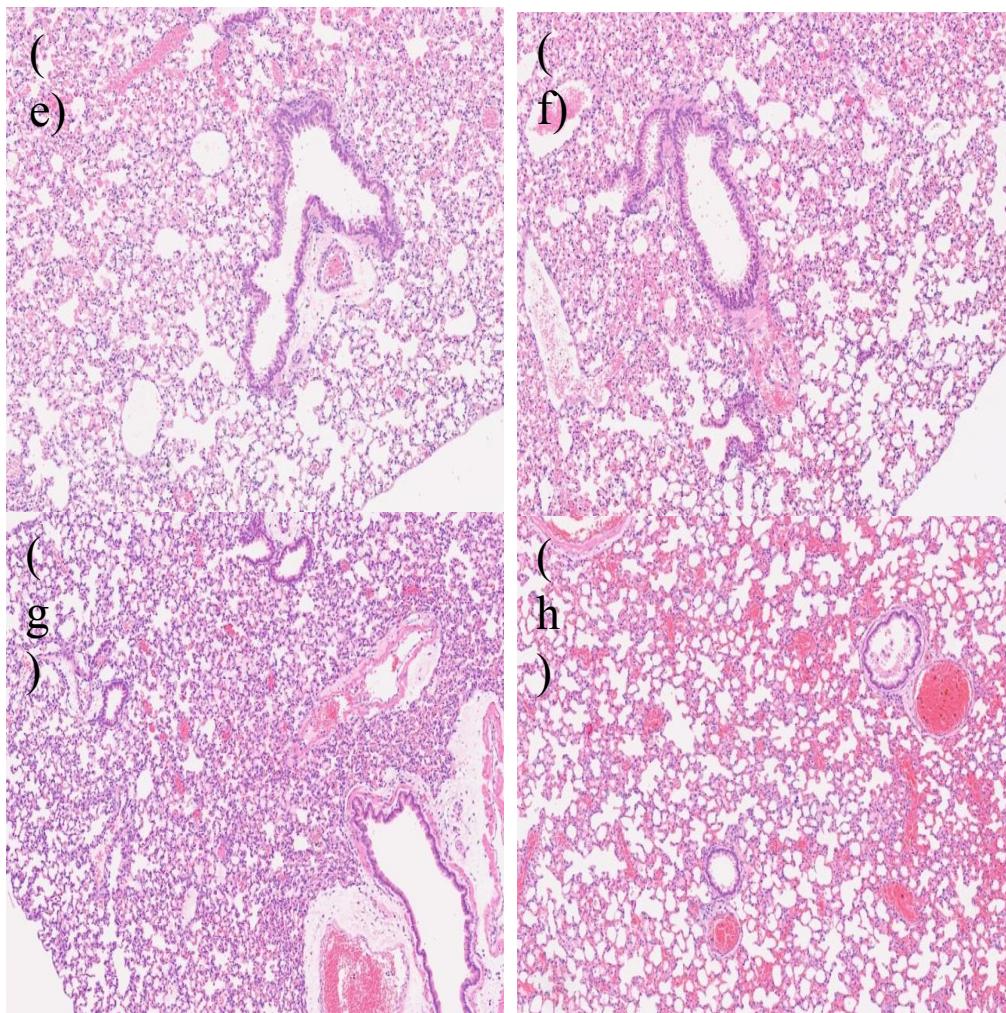
表一：試驗物質 (M61-220100457) 與試驗菌株作用 24 小時後之結果

試驗菌株	接種菌量 (CFU/mL)	單位	殘留菌量		LR	抗菌率 (%)
			對照組 立即稀釋 (A)	實驗組 作用後稀釋 (D)		
<i>S. pneumoniae</i>	2.1×10^6	CFU/mL	3.6×10^6	8.3×10^3	2.64	99.76
		Log_{10}	6.56	3.92		
<i>A. actinomycetemcomitans</i>	7.2×10^6	CFU/mL	8.5×10^6	1.2×10^3	3.85	99.98
		Log_{10}	6.93	3.08		
<i>P. gingivalis</i>	1.7×10^6	CFU/mL	1.4×10^6	<5	5.45	>99.99
		Log_{10}	6.15	<0.70		

無患子純露抑制肺臟發炎之應用

小鼠肺臟組織切片
比較
倍率10×

- (e) LPS – SMH –
- (f) LPS – SMH +
- (g) LPS + SMH –
- (h) LPS + SMH +



Trigger Nebulizer

medisize
CREATING SMARTER SOLUTIONS

medel®

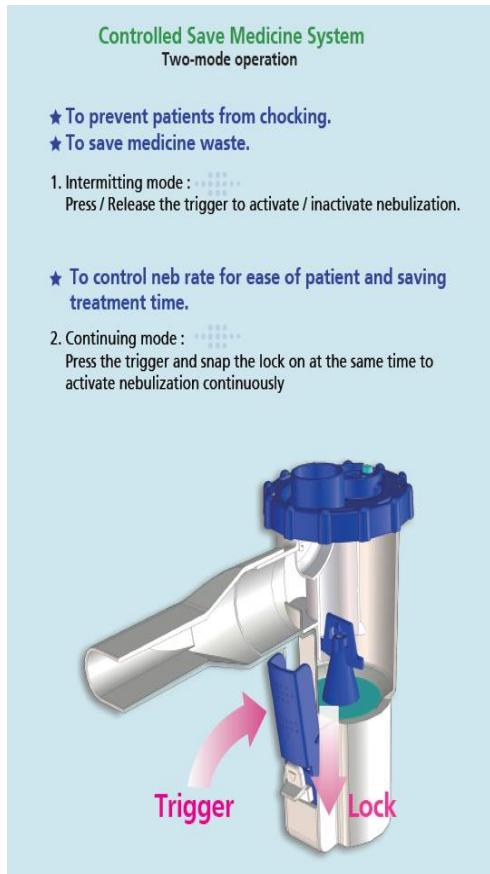
Muranaka

TriggerNeb™
BY LOGIC VENTURES

SAN-UP®

PAHSCO

PRI/MA



How does it work? AT neb closed nebulization system

The nebulizer can also be used in the continuous mode (f.e. when used in combination with a mask). For this, press the activation button, and push the lock under this button downwards. For returning to manual activation the lock has to be pushed upwards.

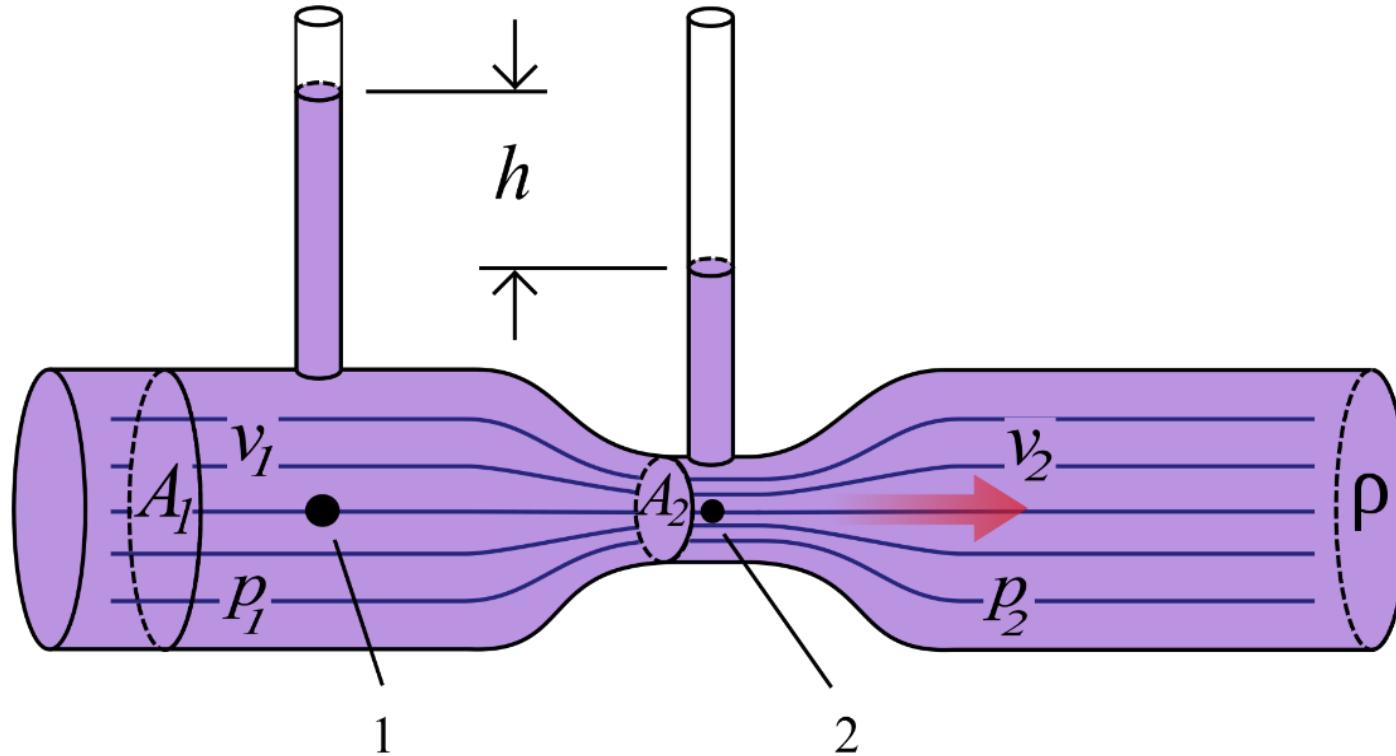
Two nebulization modes:

1. Manual activation: aerosol is only produced when pushing the button; due to this, there is no loss of medication to the environment.
2. Continuous mode: the activation button can be clicked to a firm position for continuous administration of medication.



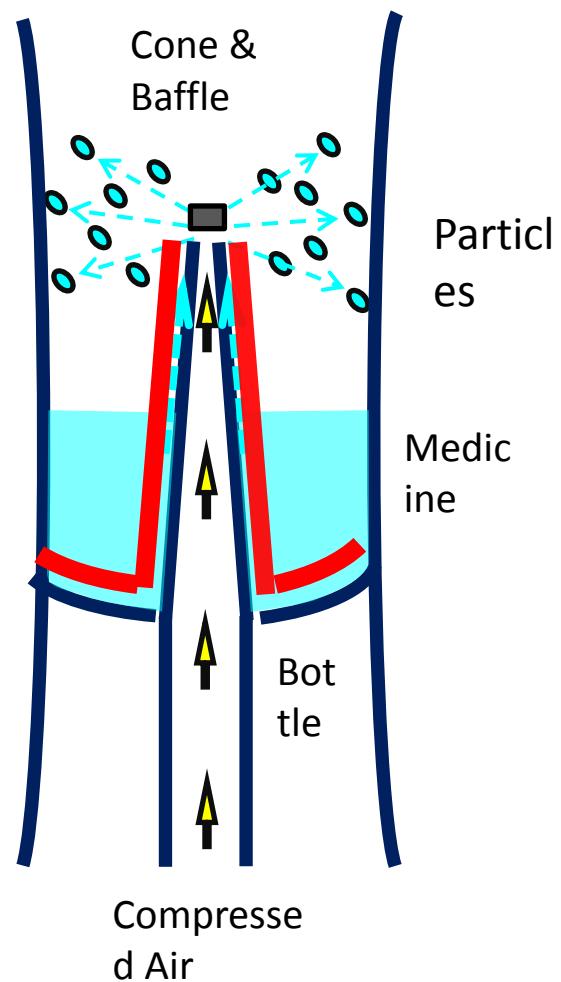
Expiration filter:
To ensure a complete closed and safe system exhalation goes via the expiration filter: this prevents that nursing staff or other patients come in contact with the exhaled medication.

How a Nebulizer Works?

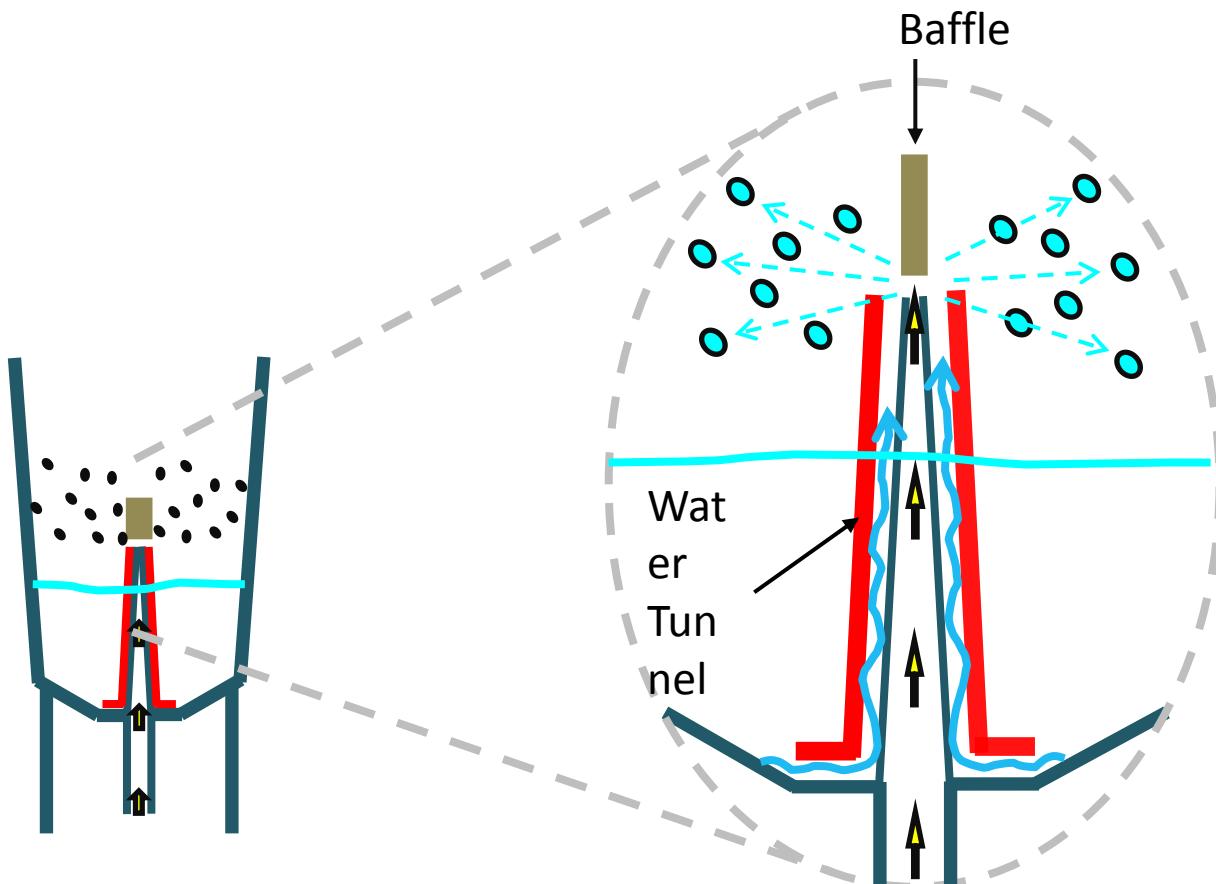


噴霧罐是一種利用伯努力定律，將藥水霧化成顆粒的裝置。

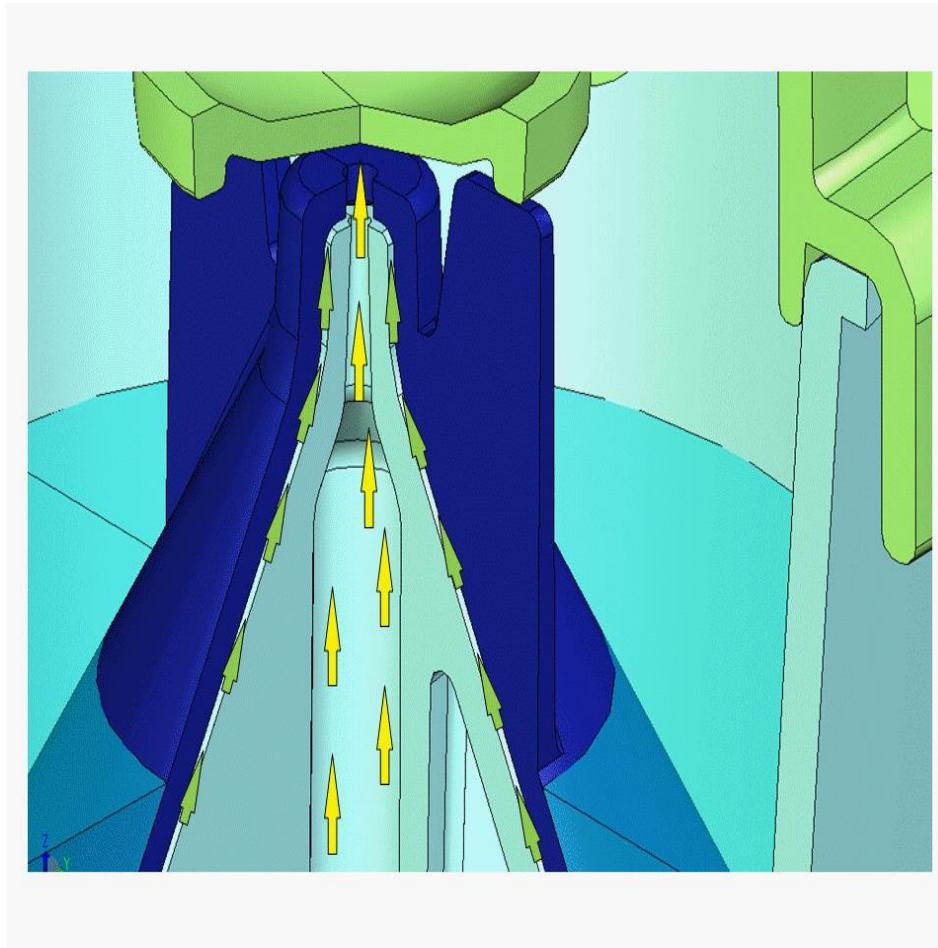
How a Nebulizer Works?



How a Nebulizer Works?



How a Nebulizer Works?

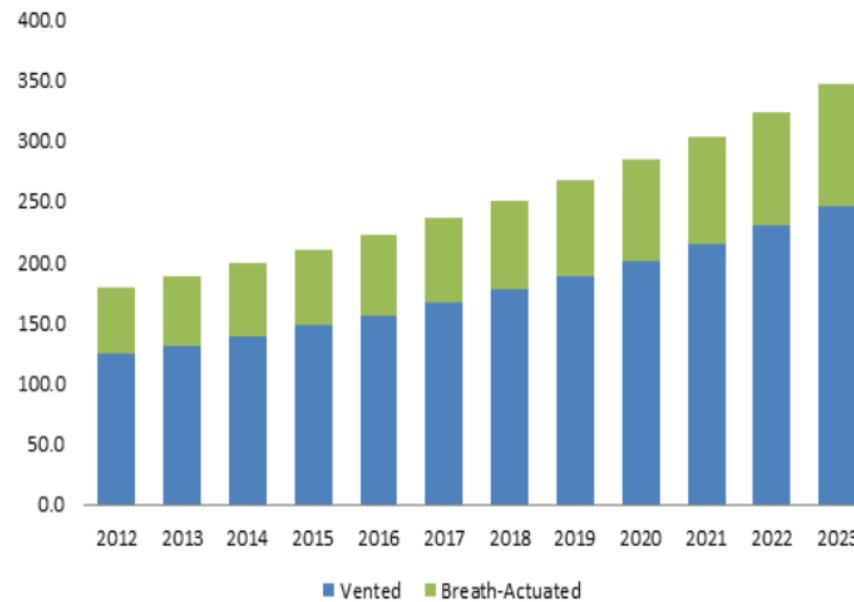


氣動式噴霧罐 (BAN) 的市況(美國地區)

Industry Trends

Pneumatic Nebulizers Market size was USD 626.2 million in 2015, with over 6% CAGR estimations from 2016 to 2023.

U.S. Pneumatic Nebulizers Market size, by product, 2012 - 2023 (USD Million)



根據一份Global Market Insight的氣動式噴霧罐的市況報告(美國地區) , 2017年美國的噴霧罐行銷約2.20億美金 , 呼吸引動式噴霧罐約占30%(6600萬美金) , 並以每年約6.3%的成長率持續增加。全世界只有一款BAN在市場上銷售。



 ALLNEB
Breath Actuated Nebulizer

自呼吸引動式噴霧罐

僅在吸氣時噴霧

杜絕藥物浪費

無負擔吸氣引動

優異的噴霧效率

– □ X



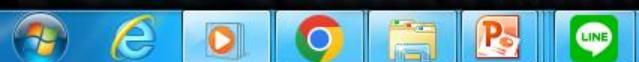
a09652f4-f988-4b4b-9e6d-950be4e88ab1



00:05



下午 11:47
2023/3/4



自主呼吸驅動式噴霧罐

減少藥物浪費并節約霧化藥物總成本

對比傳統噴霧罐，AllNeb至少可節省1/2以上的藥物浪費。

呼吸引動只在吸氣迴圈期間將處方藥霧化為懸浮粒子，在呼氣或治療中斷期間沒有藥物丟失。

呼吸引動特徵避免了患者呼氣時的藥物損失，從而減少了藥物浪費，並改善護理人員可能會接觸藥物的不利影響。

在使用昂貴藥物治療時，減少藥物浪費上具有重要優勢。



精准給藥的強大優勢

AllNeb只在患者吸氣時才會促發噴霧，在提供出色的可吸入劑量時，更出色的出霧性能實現精准給藥，直達病灶。



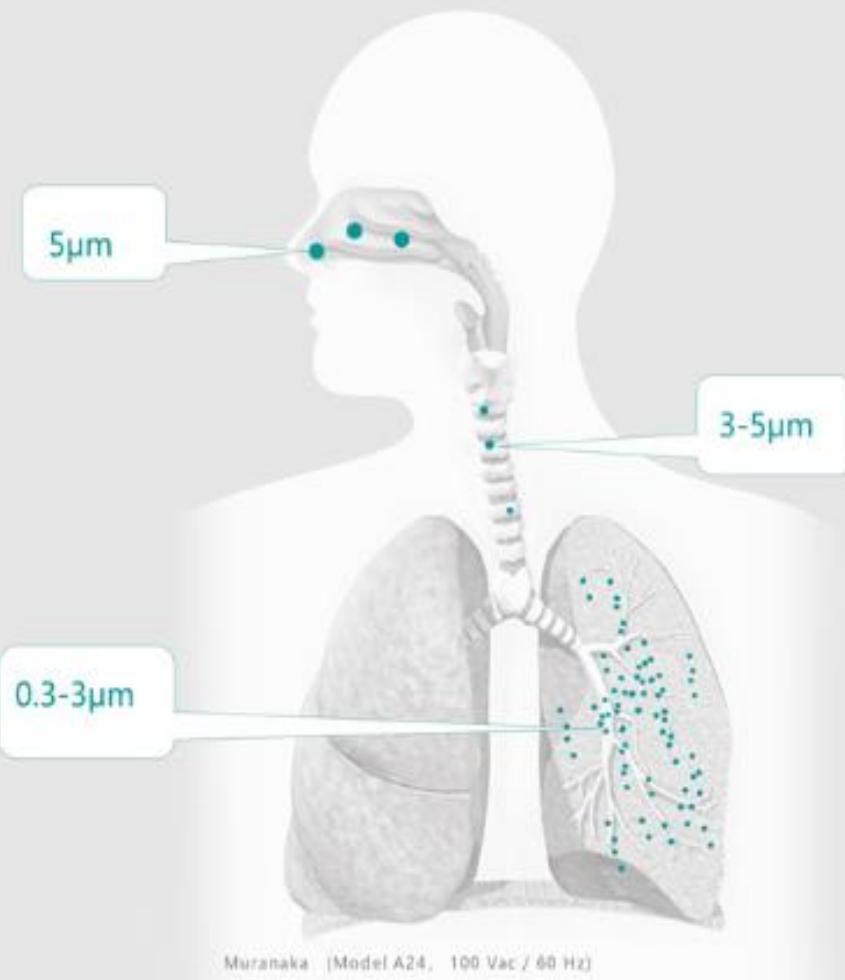
優異的霧化顆粒 藥液更容易被吸收

MMAD 1.22 μm

AllNeb高效率產生96%的有效噴霧顆粒。

根據測試報告顯示，AllNeb可以產生MMAD約
1.22 μm 大小的極細霧狀粒，讓患者更深入、更
充分、更舒適和自然。

霧化顆粒向患者的肺部提供更高百分比例的霧化藥
物劑量，更容易被肺泡吸收，精准給藥，直達病灶。



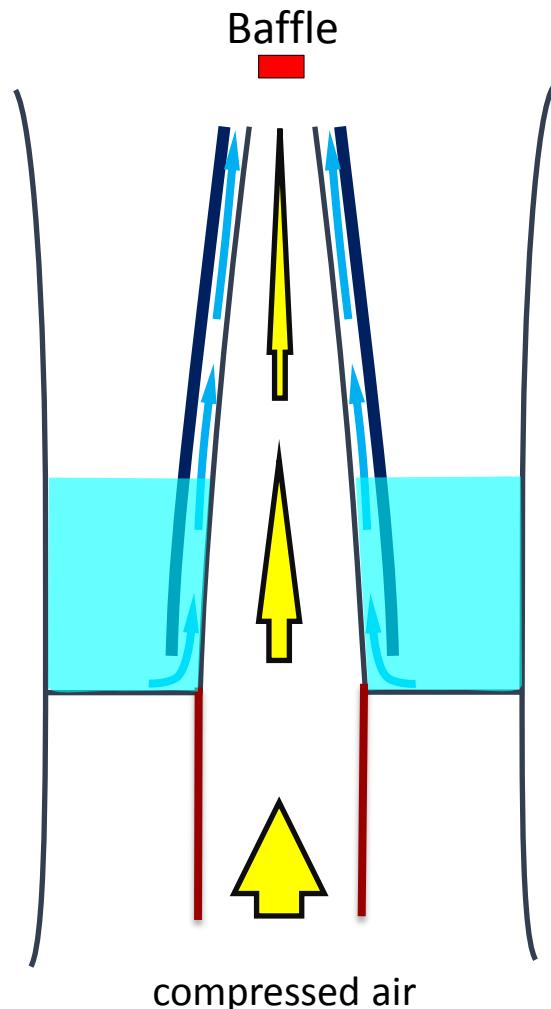
輕如薄翼的啟動流量

AllNeb吸氣阻抗低於競品BAN 約50%，在患者吸氣的一瞬間立即噴霧，依靠發明專利設計的啟動方式，患者可以很輕易通過極低的吸氣流量，讓AllNeb進入供藥噴霧狀態。

更低的阻抗，所需的吸力更小，利於患者更輕鬆舒適地吸入藥物，避免長時間用力吸氣而產生的頭暈缺氧等不適感。



How a Nebulizer Works?

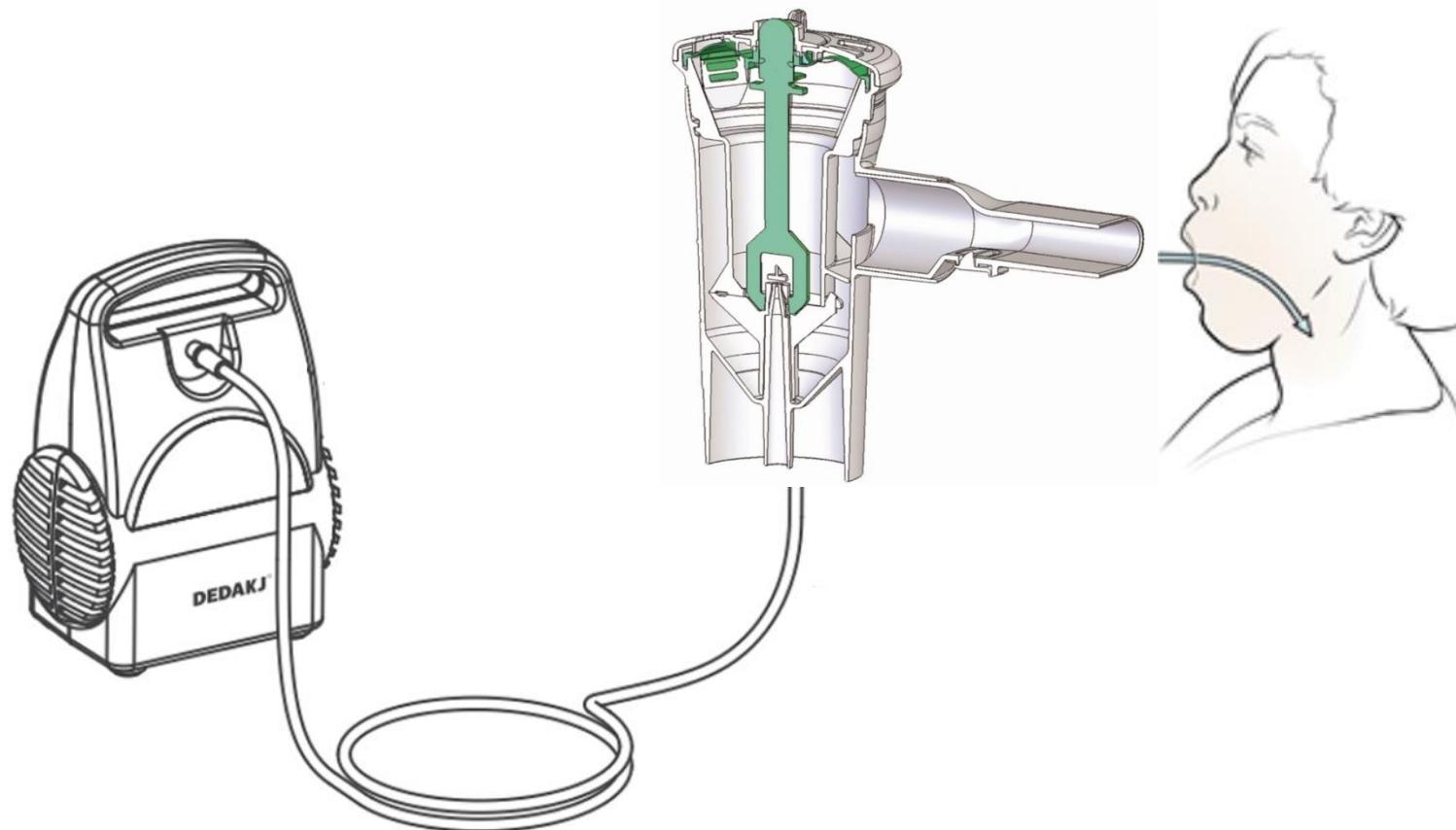


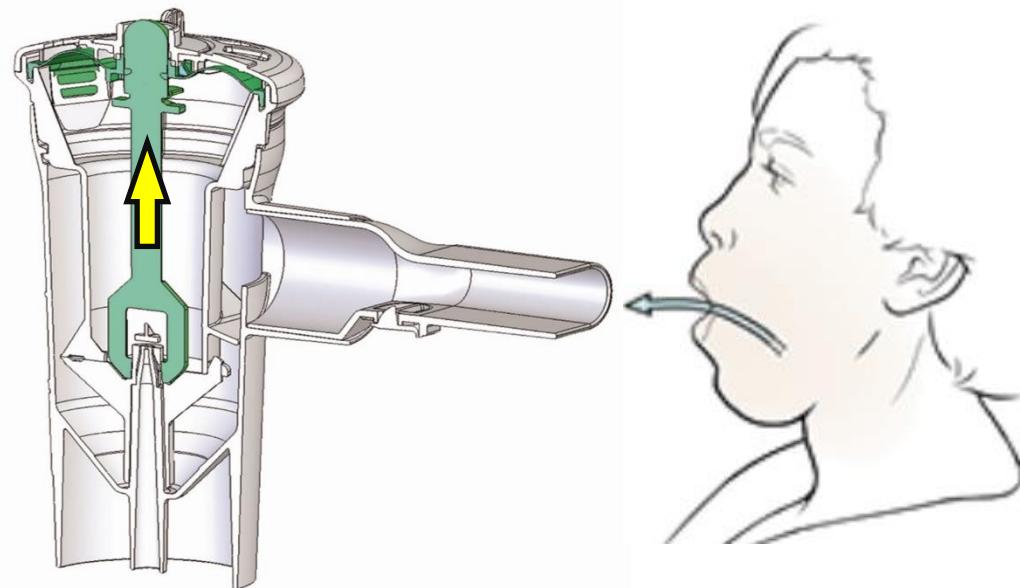
吸氣引動式噴霧罐暫時
停止的方法：

✓ 移開Baffle

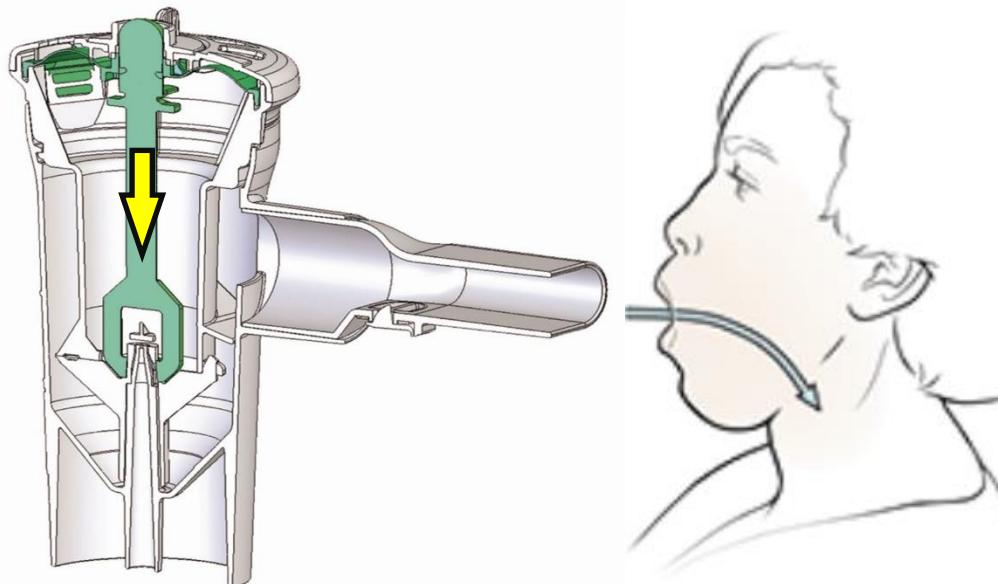
✓ 斷開水道

AEII的專利：直接負壓啟動





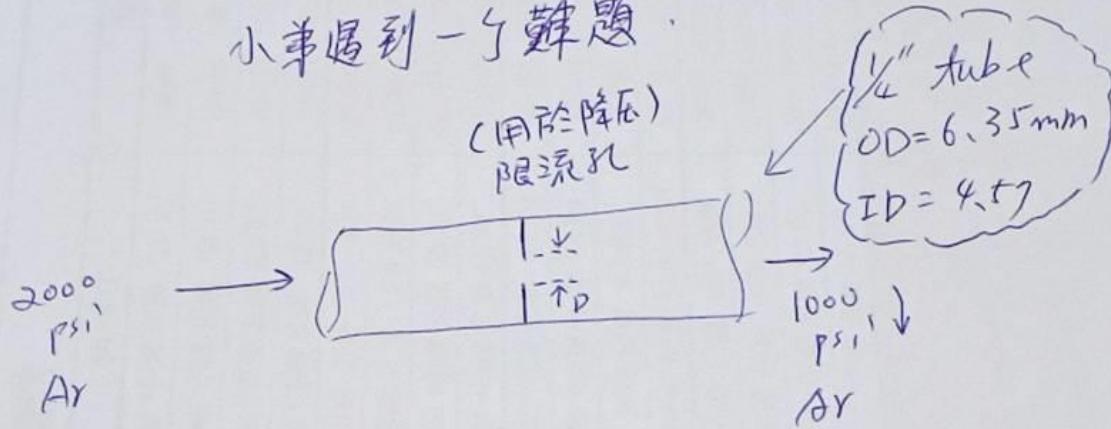
Non-Nebulization Position



Nebulization Position

各位尊敬的同學與熱流專家們：

小弟遇到一問題



請問限流孔直徑 D 要用多少

還請大家幫忙給些意見！

FYR. 這是ChatGPT的答案，僅供參考。如果有錯，請找OpenAI投訴。

要计算管子中间的限流孔的直径，需要使用伯努利方程和连续性方程来求解。

首先，根据伯努利方程，压力和速度之间存在一个关系：

$$P_1 + 0.5\rho v_1^2 = P_2 + 0.5\rho v_2^2$$

其中， P_1 和 P_2 是管子的入口和出口压力， ρ 是流体密度， v_1 和 v_2 是入口和出口的流速。

由于管子直径不变，因此入口和出口的流量相等，即 $Q_1 = Q_2$ ，其中 $Q = Av$ 是流量， A 是管子横截面积， v 是流速。

因此，根据连续性方程，可以得出：

$$A_1 v_1 = A_2 v_2$$

将 v_2 替换为 Q_2 / A_2 ，同时将 v_1 替换为 Q_1 / A_1 ，然后将其带入伯努利方程，得到：

$$P_1 + 0.5\rho(Q_1 / A_1)^2 = P_2 + 0.5\rho(Q_2 / A_2)^2$$

根据题目中给定的数据， $P_1 = 2000 \text{ psi}$ ， $P_2 = 1000 \text{ psi}$ ，管子直径为0.25英寸，因此可以计算出管子横截面积：

$$A = \pi r^2 = \pi(0.125 \text{ in})^2 = \underline{0.0491} \text{ in}^2$$

然后，可以将方程中的各个值代入，解出 Q_1 和 Q_2 的值，即：

$$Q_1 = Q_2 = A_1 v_1 = A_2 v_2$$

然后，将 Q_1 和 Q_2 的值带入连续性方程，求解出入口流速 v_1 和出口流速 v_2 ：

$$v_1 = v_2 = Q / A = Q_1 / A_1 = Q_2 / A_2$$

最后，将 v_1 的值代入伯努利方程，可以解出限流孔的直径 d ：

$$d = \sqrt{(Q_1 / (\pi v_1))^2 / \pi}$$

将 Q_1 、 v_1 的值带入计算，得到限流孔的直径 d 约为0.032英寸。