



Pediatric Burn: Pathophysiology & Management

兒童燒燙傷的治療

- 2024/05/14 台北榮民總醫院
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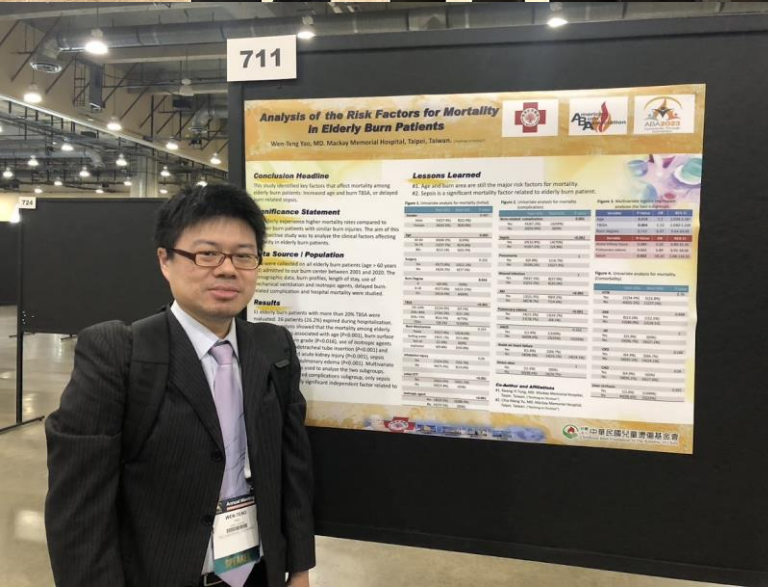
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自介

- Born in 1982
- Plastic and reconstructive surgeon(2014~)
- Chief of burn center (2020~)
- Member of Taiwan society for Burn Injuries and Wound Healing
- Interest: Microsurgery, Burn, Marathon





課程大綱

1. 兒童燒燙傷的生理學
2. 兒童燒燙傷的評估
3. 兒童燒燙傷的治療



Child Burn

Critical care of the
burned patient

A child is not just a small adult, but a person who is ever more devastated by the burn injury, and who is less able to respond to it.

Edited by:
Lindsey T.A. Rylah

Lindsey T.A. Rylah, 1992



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Burn Types

Thermal

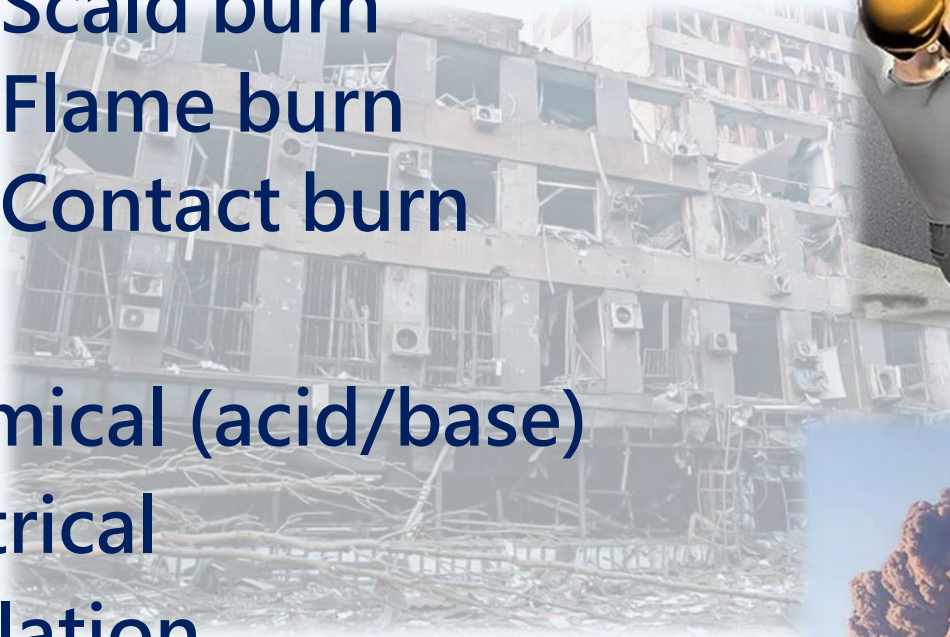
- ❑ Scald burn
- ❑ Flame burn
- ❑ Contact burn

Chemical (acid/base)

Electrical

Inhalation

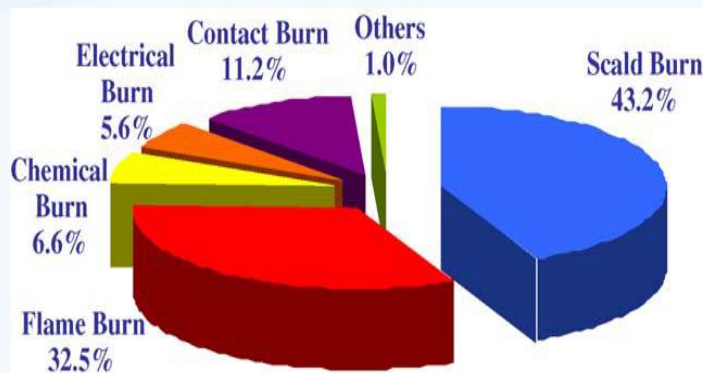
Blast



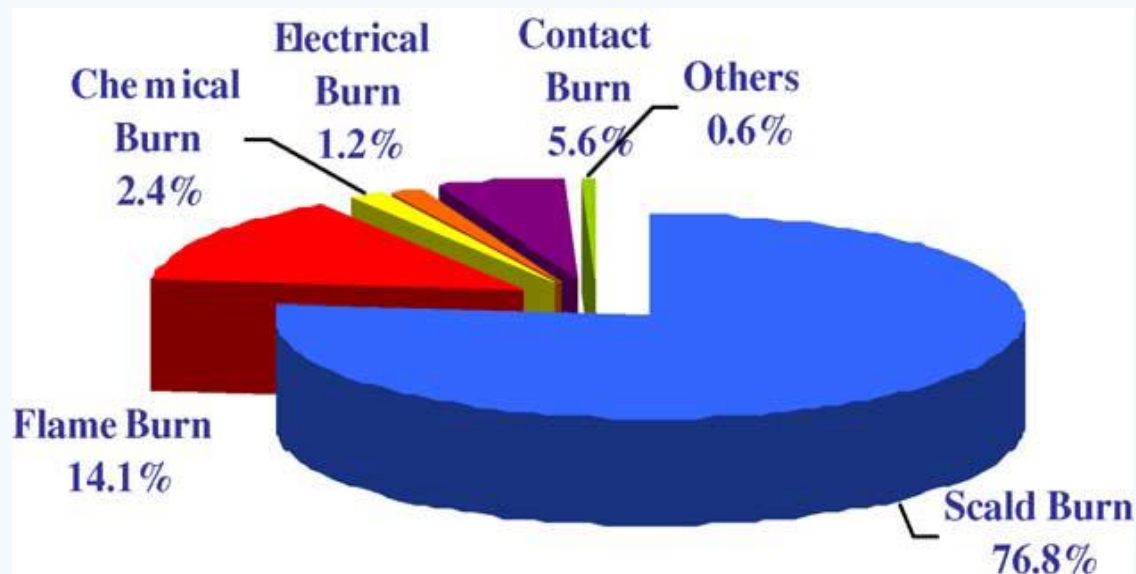
Types of Burn in Children Patients

(3,825 cases)

Adult



Children

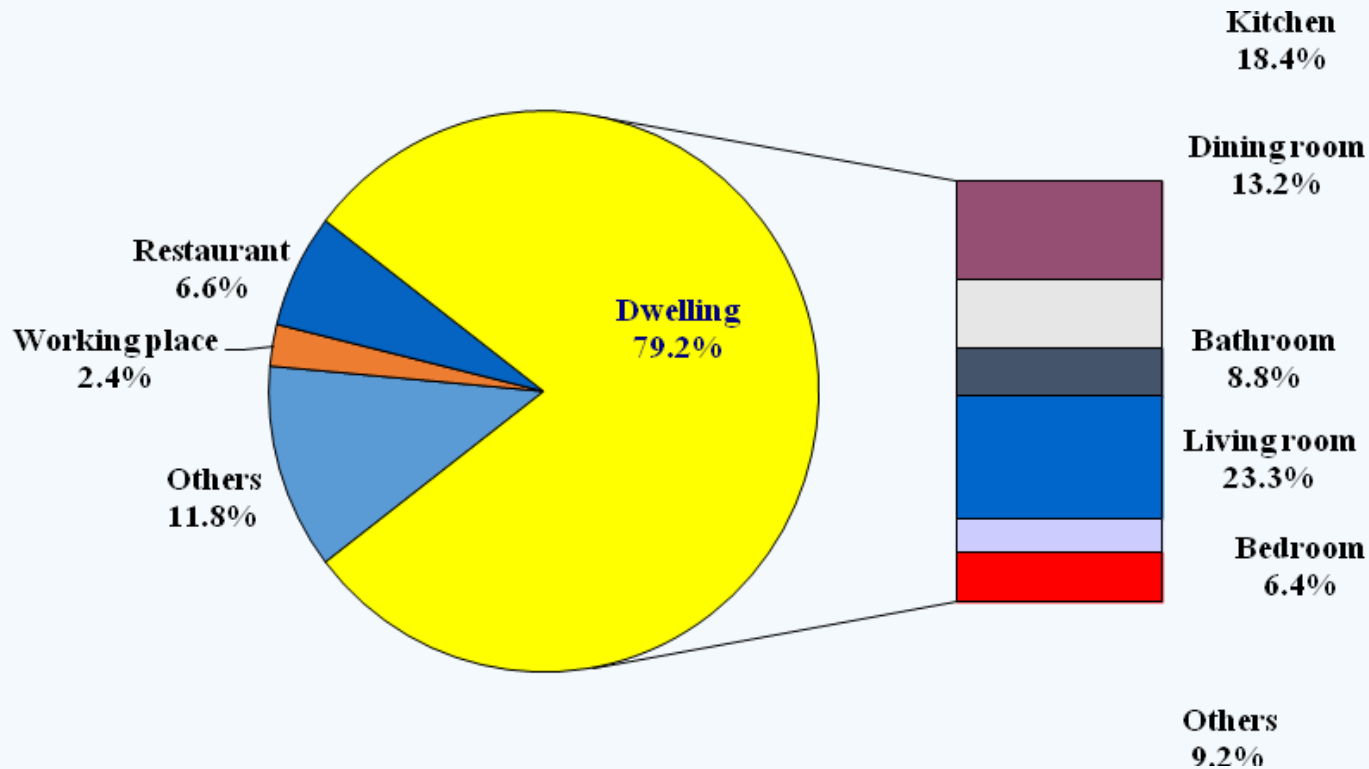


1. 熱飲用水 (Hot drinking water) 33.7%
2. 熱湯及飲料 (Hot soup and drinks) 27.2%
3. 熱洗澡水 (Hot bathing water) 5.4%
4. 熱食品 (Hot food) 3.3%
5. 熱自來水 (Hot tap water) 3.3%。



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Places of Burn Injuries in Children Patients (3,825 cases)



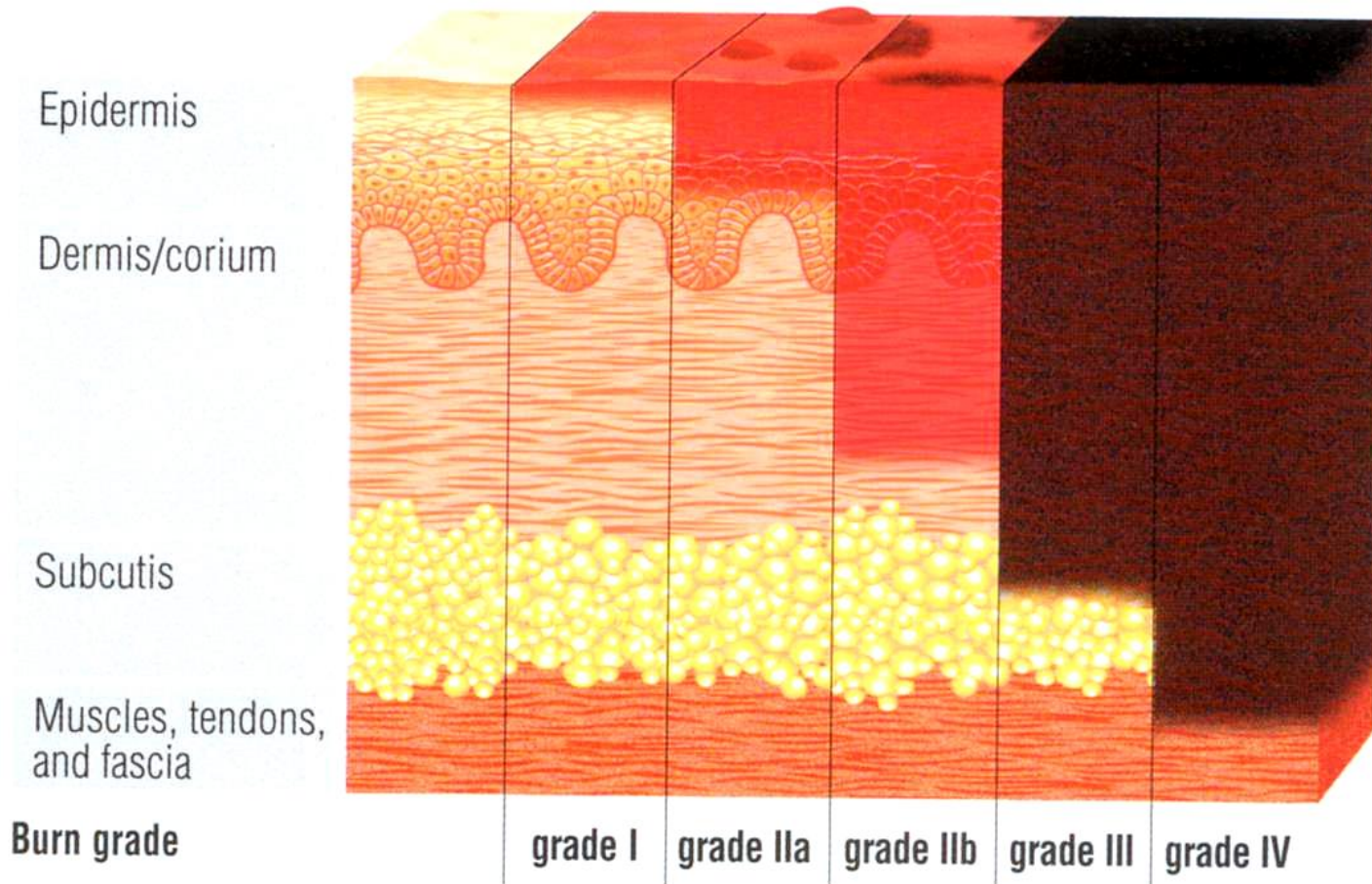
🏠 居家場所 dwelling place: 79.2%

🏠 客廳和廚房 Living room and kitchen.



Burn Depth

- *Same burn depth classification as adult*



Differences of Child Burn

- Thin skin: underestimate the depth of burn
皮膚薄，造成低估燒傷的深度
- Immature temperature regulation
不成熟的溫度調節
- Higher basal metabolic rate 較高的基礎代謝率
- Immature organ functions 不成熟的器官功能
- Higher incidence of pulmonary and cerebral edema 肺和腦水腫的發生率較高

Consequences of loss of Barrier Function

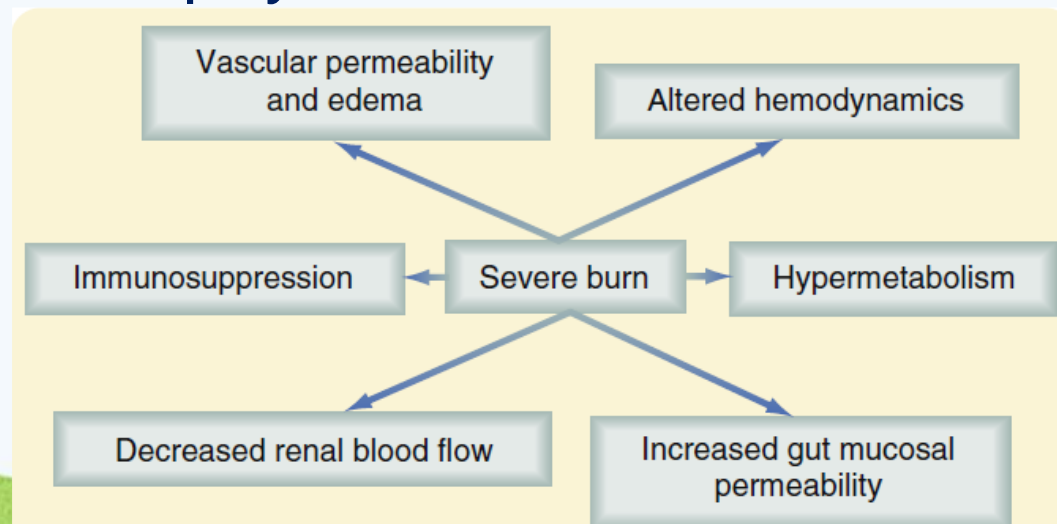
- Loss of the epidermal barrier has serious adverse physiologic effects.
- Open wounds present a high risk of fluid loss, high inflammation bacterial colonization, infection, and sepsis. 體液流失, 易感染



Hypermetabolism

- Typically 3 to 4 days after major burn
- Characteristics:
 - Tachycardia
 - Increased cardiac output
 - Elevated energy expenditure
 - Increased oxygen consumption
 - Massive proteolysis and lipolysis

Systemic effect of severe burn



Burn Hypermetabolism

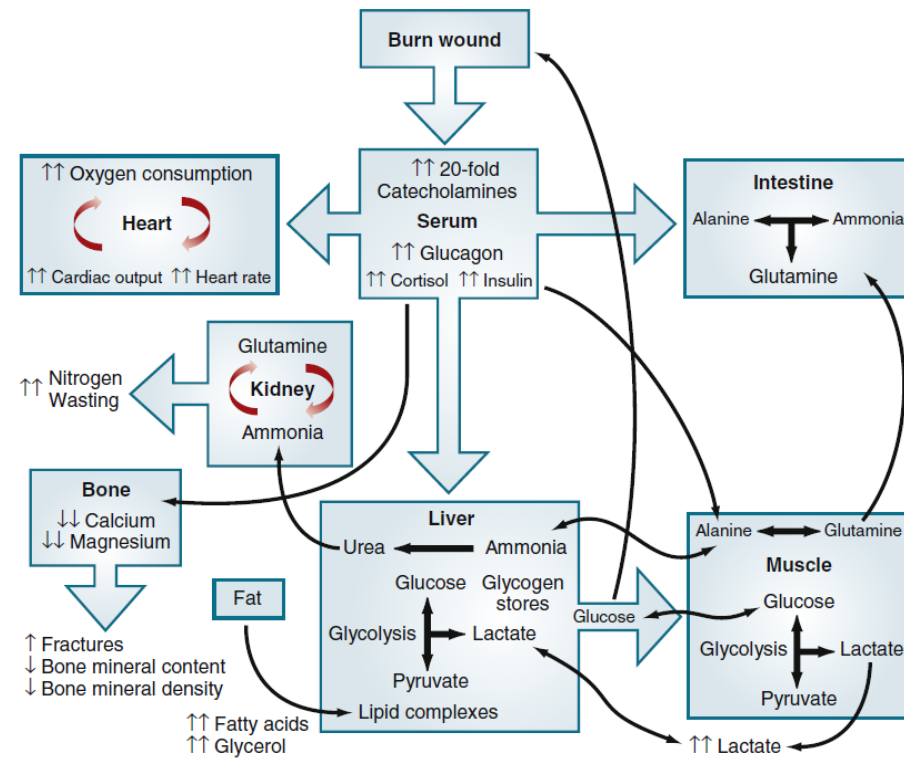
- Profound hypermetabolism is a classic feature of children with large burn injury.
- Slows wound healing
- Prolongs generalized weakness
- Loss of lean body mass
- Burn size ↑ , Response ↑

Long term effect of Hypermetabolism

- **Cardiac dysfunction**
 - 60% long term
 - Systolic dysfunction was observed in 62% of patients ($EF \leq 50\%$)
- **Growth arrest** (nearly a year after burn in children)
- **Depression, anxiety**
- **PTSD (Post-traumatic stress disorder)**

Pathophysiology

- Oxygen consumption
- Muscle protein breakdown
- Endocrine alterations (Cortisol, Catecholamines, Glucagon, Growth hormone)
- Negative nitrogen balance
- Ion losses
- Proteolysis
- lipolysis



Management

- *Metabolic modulation and treatment after burn*
 - Temperature/Evaporative control
 - Operation room 29-32 °C/ Ward temperature 30-32 °C
 - Core temperature 37.5 °C
 - Nutrition
 - Caloric needs 20-60% increase
 - Protein requirements massively increase
 - Vitamins C, E
 - Zinc



Management

- *Metabolic modulation and treatment after burn (Treatment of 3rd degree Burn)*
 - Early total excision and grafting
 - Excision of full thickness burn wounds within 24~48 hrs
 - Decrease mortality rate. Lower Sepsis rate
 - Occlusive dressings have been shown benefits (e.g. Artificial dermis)





- 3 year-old boy
- 2nd~ 3rd degree burn
- 26% TBSA
- Debridement & artificial dermis cover



Management

- *Metabolic modulation and treatment after burn*
 - Exercise
 - Various types of in-hospital 6- to 12-week exercise regimens, have been shown to improve various parameters of cardiorespiratory fitness in adults and children .



In hospital exercise



Pharmacologic agents

- Insulin
 - Metformin
 - Propranolol
 - Ketoconazole
 - Anabolic steroids
- 160-180mg/dl
- Decrease Cardiac work



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Five Steps of First Aid of Cooling



 Only 4.1% of all burn cases could actually perform the full 5-step first aid.



Emergency Burn Care

- Primary Survey
 - **A**irway
 - **B**reathing
 - **C**irculation



Emergency Burn Care

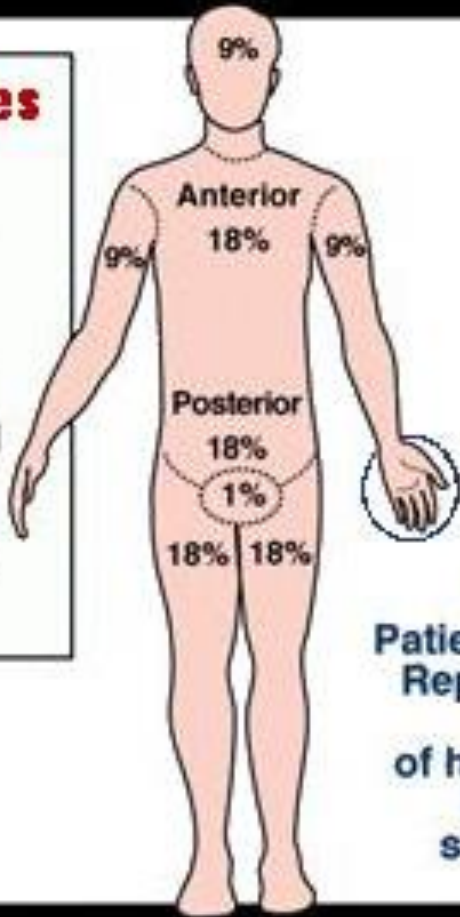
- Secondary Survey
- Detailed history 詳細的病史
- AMPLE: Allergy, Medications, Previous illness, Last meal, and Events preceding the injury 過敏史, 用藥史, 過去病史(先天疾病), 最後進食時間, 受傷當下在做什麼事情
- Comprehensive physical examination
- From head to toe: associated injuries
- Burn wound: last one on the check list



Burn Extent

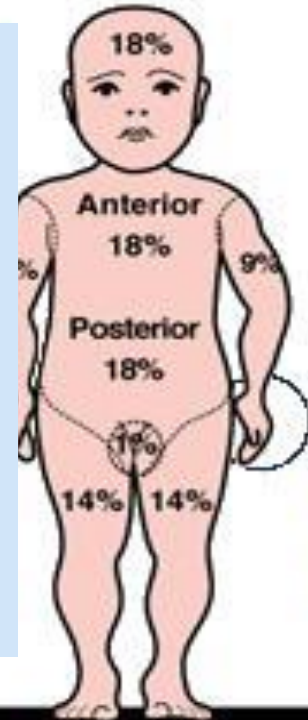
Rule of Nines

The body surface is divided into areas representing 9% or multiples



The Patient's Palm Represents 1% of his or her body surface

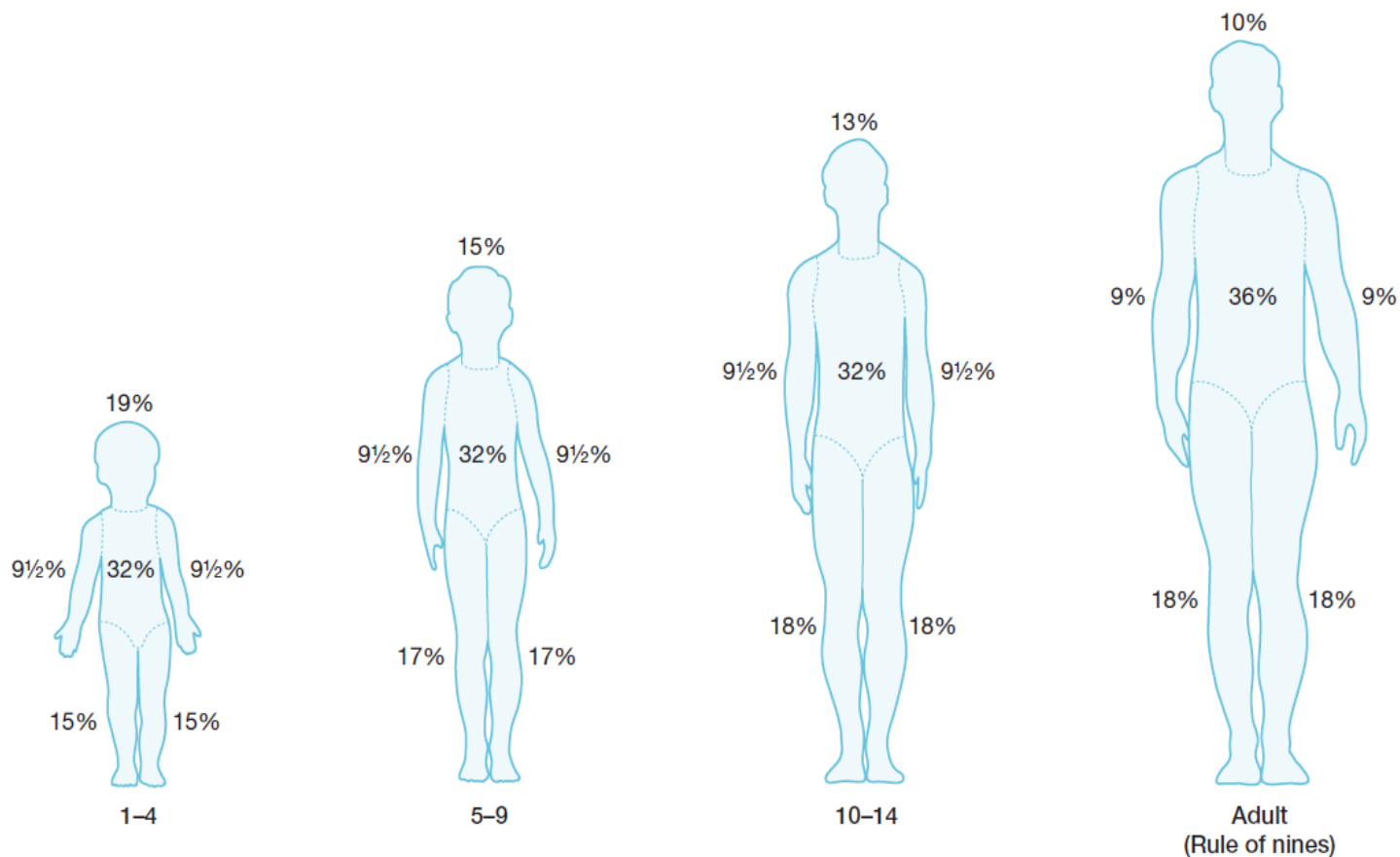
Rule of 9 is **not** applicable because that head is relatively larger than adult.



The Child's Palm Represents 1% of his or her body

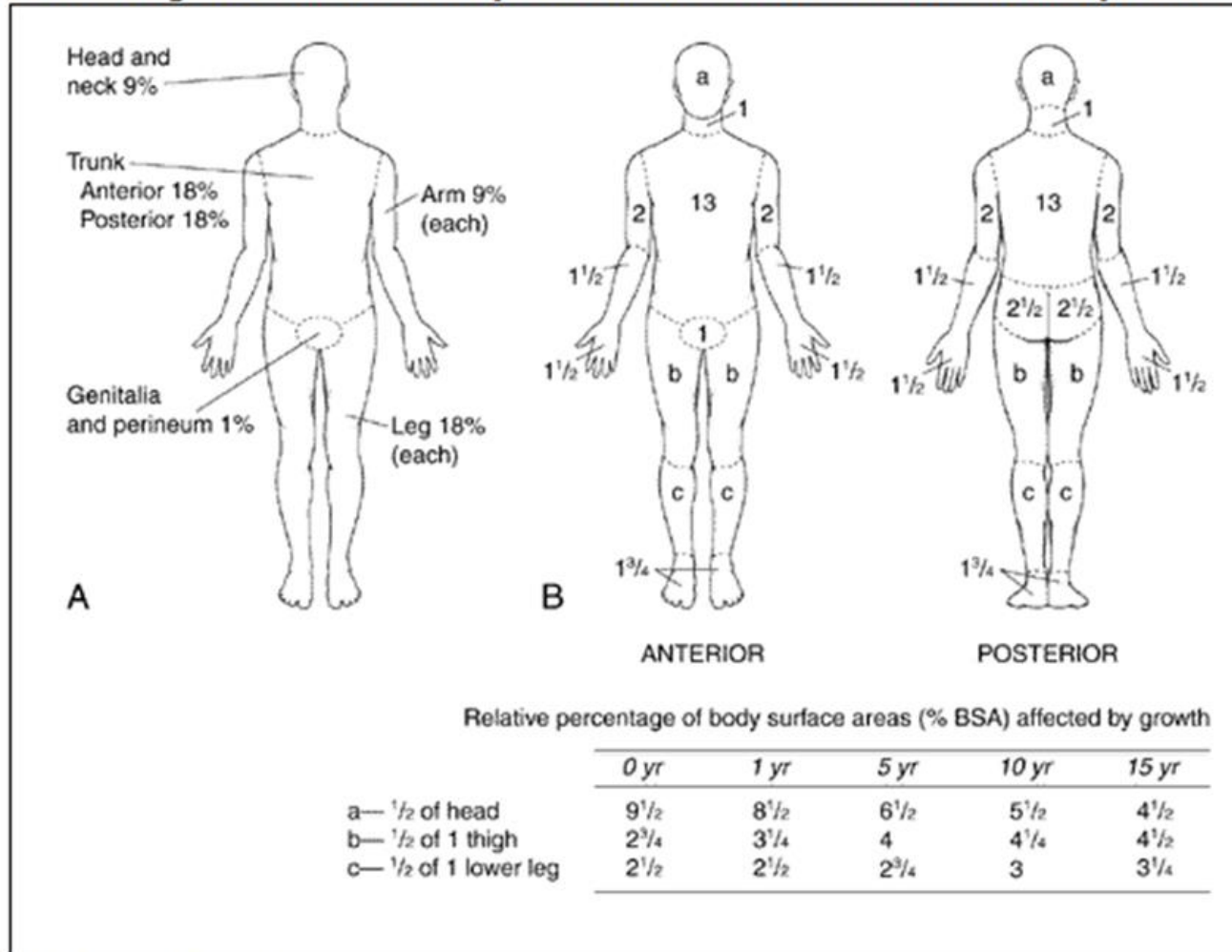


兒童頭較大,軀幹四肢較小



Burn Extent Assessment

Estimating Percent Total Body Surface Area in Children Affected by Burns



(A) Rule of "nines"

(B) Lund-Browder diagram for estimating extent of burns

需評估是否為兒童虐待 Child Abuse

檢查項目 / 重點	評估指標
傷痕之界限	<ul style="list-style-type: none"> ■ 虐待性燒燙傷跟周圍健康組織有一個非常明顯的界線，一般意外燒燙傷會有一個漸進過渡的區域
傷痕之形狀	<ul style="list-style-type: none"> ■ 臀部會陰部的燙傷 最常見的虐待性燒燙傷是將兒童浸泡到熱水「甜甜圈的洞」及「斑馬紋」，是浸泡虐待燙傷的強烈證據 <div data-bbox="724 564 1371 878">  <p>浸泡熱水 浸泡燙傷區域 斑馬紋 甜甜圈的洞</p> </div> <ul style="list-style-type: none"> ■ 四肢燙傷 燙傷傷口邊緣和正常皮膚有明顯界限，若發生在四肢，形成所謂「手套」和「長襪」形狀 <div data-bbox="888 1013 1217 1220">  <p>長襪狀燙傷</p> </div> <ul style="list-style-type: none"> ■ 香菸燒傷 圓形一致的深度燒傷、與香菸的直徑比對，可助診斷 ■ 烙印燒傷 特殊形狀的接觸燒燙傷，例如電熨斗或電捲棒



是否為兒童虐待 Child Abuse

- ✓ **History** 病史
 - 延遲就醫
 - 多處燒燙傷
 - 安靜而反應遲鈍的孩子
 - 未能正常發育成長且無法溝通
- ✓ **Pattern of burn injury** 燒燙傷的型態
 - 沒有飛濺的痕跡
 - 清楚劃定出水線或具對稱性的傷害
 - 身體通常覆蓋部位的接觸性燒傷
- ✓ **Bruises, whip marks, fractures and head trauma** 合
併瘀傷、鞭痕、骨折和頭部外傷



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Special Considerations in fluid therapy

- Infants/toddlers: maintenance fluid > Parkland formula
- Goal of urinary output is higher in kids (1ml/kg/hr)
- Infants are susceptible to **hypoglycemia**
 - In first 24 hrs 在第一個24小時，嬰兒容易發生低血糖
 - Frequent monitoring of blood sugar and giving glucose containing solutions
- **Hyponatremia**, Hypochloremia
- Hypophosphatemia
- **Hypothermia**



Fluid Resuscitation for 1st 24 Hours

- ✓ Burn shock
- ✓ **Infants >10 %TBSA**
children > 15% TBSA
adult > 20% TBSA
- ✓ > 40 % TBSA: central line
- ✓ Parkland formula for adult patient :
 - 4 cc/kg/%TBSA Ringer's lactate
- ✓ Gerard van Swieten: rectal fluid



1700 – 1772



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Fluid Resuscitation for 1st 24 Hours

- ✓ Children= daily maintenance fluid + burn loss
- ✓ Maintenance fluid + 3 ml/kg/% burn: Ringer's lactate

Shriner's Cincinnati (For Children)	LR: 4 mL/kg/%TBSA burn + 1500 mL/m ² , ½ given over first 8 h and the remaining over the next 16 h (older children)
	LR: 4 mL/kg/%TBSA burn + 1500 mL/m ² + 50 mEq sodium bicarbonate for the first 8 h, followed by LR alone in second 8 h, followed by 5% albumin in LR in third 8 h (younger children)
Galveston Formula (For Children)	LR: 5000 mL/m ² burn + 2000 mL/m ² total, ½ volume in first 8 h, followed by remainder in 16 h.

- ✓ **Shriner's Cincinnati and Galveston Formula Formula**
- ✓ Record hourly urine output
- ✓ Familiar method and individually adjusted based on clinical response
- ✓ Goal directed therapy- invasive thermodilution (TDD)
- ✓ Computerized Decision Support System (CDSS)



Fluid for 2nd 24 Hours

- Capillary permeability returned to normal
- Fresh frozen plasma (0.5 ml/kg/% TBSA burn)
補充新鮮冰凍血漿或白蛋白
 - > 20 % TBSA
- Resuscitation fluids (2nd 24 hours)
 - Adults: adequate urinary output
 - Children: half normal saline for adequate urinary output
兒童以半生理鹽水維持足夠尿量
 - (1/2 ~ 3/4 amount of 1st post-burn day)
 - No free water! (CNS sensitive to hyponatremia)
 - Cardiac output



Other common complications

- Acute gastric dilatation 急性胃擴張
- Hypertension 高血壓
- 大面積燒燙傷兒童中20%可能的特發性反應，發生於受傷後數周至恢復的初期之間。
- 通常表現為煩躁不安、哭鬧和摩擦敲打頭部，或根本沒有任何症狀。
- Treatment: Hydrazaline, reserpine...
- Curling's ulcer
- H2 blocker H2受體阻斷劑



Prevention of Sepsis

- **Burn wound sepsis may occur earlier** (2-4 days) and at lower colony counts (> 1000 per gram of eschar)-
- rapid clinical deterioration
- Prophylactic antibiotics for B-hemolytic streptococcus infection
- Antibiotics according to culture and perioperative



Temporary Skin Substitutes and Dressings

- A moist environment and protection against bacterial invasion
- Wound dressings for partial-thickness wounds should:
 - *Provide a moist environment*
 - *Protect the wound from excessive fluid loss and bacterial invasion.*
 - *Require a limited number of dressing changes.*

Dressing Choice

- ✓ Antibiotics ointment
- ✓ Silver sulfadiazine
- ✓ Synthetic dressing
- ✓ Medical grade honey
- ✓ Enzyme



Mepilex® Ag



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Enzymatic debridement

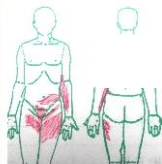
- NexoBrid™ (MediWound, Israel) is a bromelain-based enzymatic debriding agent approved for clinical use in the European Union in December 2012.



2nd degree burn

57918884
2022/08/31

scald burn
II, 8% TBSA



Mepilex-Ag



Synthetic Dressing

2~3rd degree burn



3rd degree Burn with Eschar formation



- 2 year-old boy
- 2nd~ 3rd degree burn
- 14% TBSA
- Medical grade honey+ Synthetic dressing

scald burn
II-III, 14% TBSA
44507115
2023/05/31



2 days



3 days



4 days

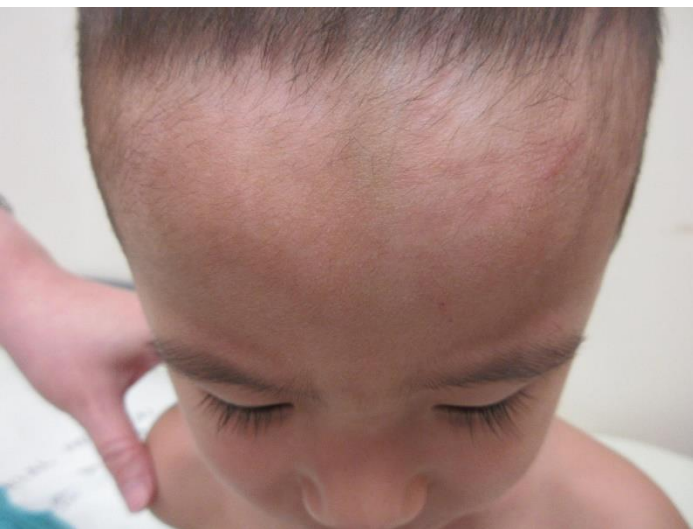




scald burn
II-III, 14% TBSA
44507115
2023/06/05

7 days



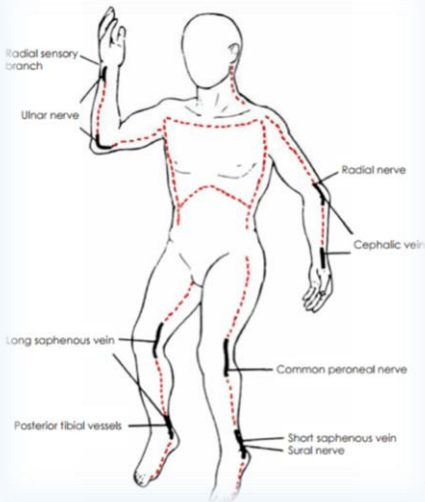


2 months



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Surgical management



- Escharotomy
- Debridement
- Skin substitutes
- Skin grafts

STSG

FTSG

Sheet

Mesh

Meek

Stamp



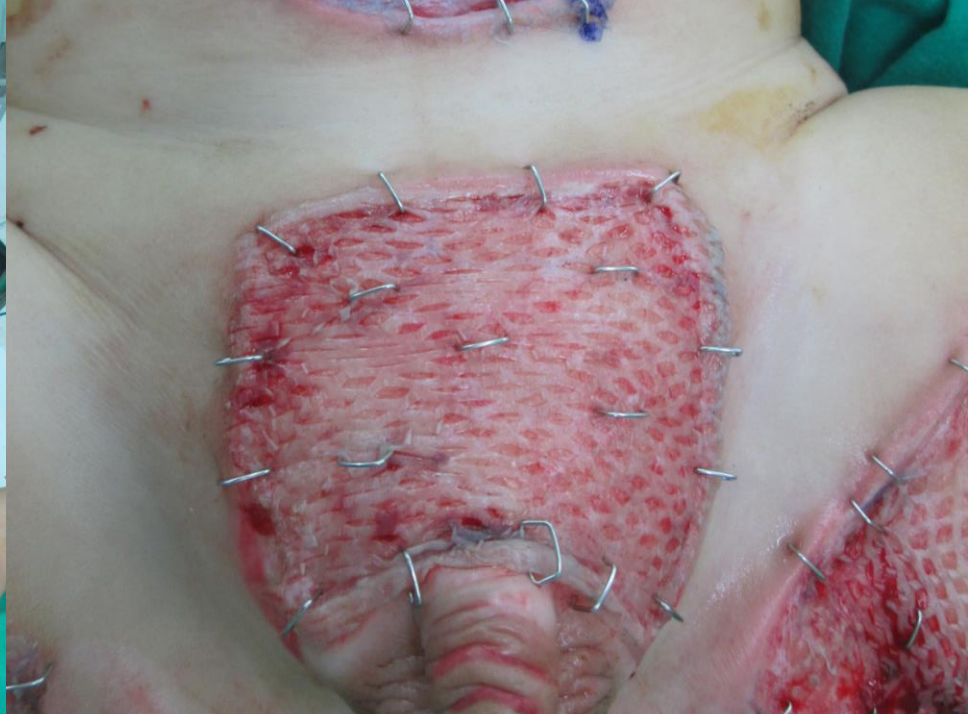




Sheet skin grafts



Biatain Alginate



Mesh skin graft





- 3 year-old boy
- 2nd~ 3rd degree burn
- 26% TBSA
- Debridement & artificial dermis cover





2019/09/16



右腰

54177432
2019/9/16
D+STSG



- Skin graft

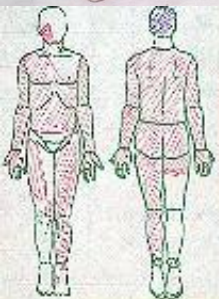


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- 2 years later
- Hypertrophic scar
- Normal exercise





- 3 year-old girl
- 2nd~ 3rd degree burn
- 65% TBSA







- 5 times of surgery
- Discharge after 2 months
- Birthday celebration





6 months later

Growth curve

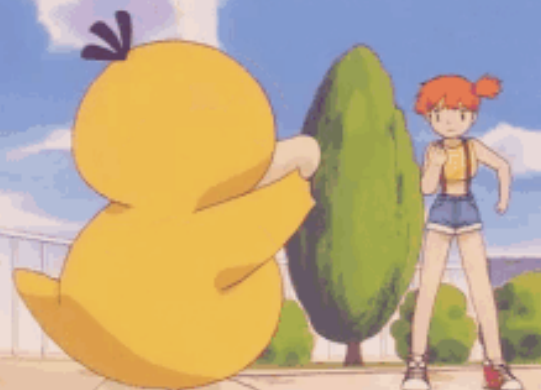
Age	Height	Weight
3 y/o	92cm (15-50%)	17kg (85-97%)
7 y/o	114cm (3-15%)	27kg (50-85%)
9 y/o	130cm (15-50%)	44kg (>97%)
11 y/o	140cm (15-50%)	50kg (85-97%)



8 years later
(11 year-old)



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Take home messages:

#1. Always keep in mind burn hypermetabolism

#2. Early intervention: glucose, fluid resuscitation, antibiotics

#3. Early debridement, artificial dermis or skin graft



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