

# Combined Radiation Injuries after the Chernobyl Accident: Management, Outcome, Lessons Learned

Medical Countermeasures against Combined Injury:  
Radiation with Burn, Trauma and/or Sepsis  
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# Presentation Outlines

- **Etiology and Pathophysiology of Radiation Skin Lesions**
- **Cutaneous Radiation Injuries in Patients with Acute Radiation Syndrome after the Chernobyl Accident**
- **Chernobyl Experience in Treatment of Cutaneous Radiation Syndrome (CRS)**
- **Chronic Sequelae of the Acute Radiation Skin Burns**
- **Current Diagnostic and Therapeutic Principles of CRS**

# The Severity and Outcome of ARS in Chernobyl Victims

ARS Grade	Dose (Gy)	Number of Patients			
		Total	Alive	Died ( <b>days to death</b> )	
<b>I</b>	0.8 -2.1	31	31	0	
<b>II</b>	2.0 - 4.0	43	42	1	<b>96</b>
<b>III</b>	4.2 - 6.3	21	14	7	<b>16 - 48</b>
<b>IV</b>	6.0 –16.0	20	1	19	<b>14 - 91</b>
<b>TOTAL</b>		<b>115</b>	<b>88</b>	<b>27</b>	

*Baranov et al, Antibiotics and Chemotherapy, 1989, 34, 7, 555-558; Guskova et al, "Acute Radiation Effects in Exposed Persons at the Chernobyl Atomic Power Station Accident" Medical Radiology, 1986, pp. 3-18.*

# Non-bone marrow syndromes caused by radiation exposure

<b>Acute Radiation Syndrome</b>	<b>Skin burns (%)</b>	<b>Oropharyngeal Syndrome (%)</b>	<b>Gastro-intestinal (%)</b>	<b>Radiation Pneumonitis (%)</b>
<b>115</b>	<b>56 (48.6)</b>	<b>80 (69.5)</b>	<b>17 (14.7)</b>	<b>7 (6.1)</b>

*Barabanova A., Vojnosanit Pregl. 2006 May;63(5):477-80*

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# Number of Deaths from Direct Radiation Effects in first 3 months

Number of patients died (TOTAL = 27)	Days of death after the exposure	Comments
<b>22</b>	14 - 34	In 20/22 patients $\beta$ -burns were the main cause of death
<b>5</b>	48 – 99*	Died after the bone marrow recovery stage  * Patient on Day #96 died from ischemic stroke

*Baranov et al, Antibiotics and Chemotherapy, 1989, 34, 7, 555-558; Guskova et al, "Acute Radiation Effects in Exposed Persons at the Chernobyl Atomic Power Station Accident" Medical Radiology, 1986, pp. 3-18.*

# Varying Severity of Skin Damage in Patients with ARS

Severity (Grade) of Acute Radiation Syndrome (ARS)	Number of Patients with ARS	Percentage of skin involvement in patients with ARS			
		50%	10-50%	1-10%	TOTAL
IV	20	9	10	1	20
III	21	3	15	3	21
II	43	1	9	2	12
I	31	0	1	2	3
<b>TOTAL</b>	<b>115</b>	<b>13</b>	<b>35</b>	<b>8</b>	<b>56</b>

*Guskova et al, Acute radiation effects in exposed persons at the Chernobyl Atomic Power Station Accident, Soviet Radiology, 1986 (article in Russian)*

# Stages of CRS

Stage	Onset	Symptoms
<b>Prodromal</b>	24-72 hours	Transient erythema, pruritis
<b>Manifestation</b>	Days – 4 weeks	Intense erythema, edema, pruritis, pain, blisters, erosions, ulcerative necrosis
<b>Subacute</b>	4-6 weeks	Erythema, edema, ulcers
<b>Chronic</b>	3 months-2 years	Keratosis, fibrosis, ulcer, atrophy, pigment alteration, subcutaneous vasculitis, ulceration
<b>Late</b>	Decades	Ulcers, angioma, fibrosis, keratosis, basal cell carcinoma

*Stages of the CRS according to Second Consensus Development Conference on the Management of Radiation Injuries, Bethesda, MD, 1993*

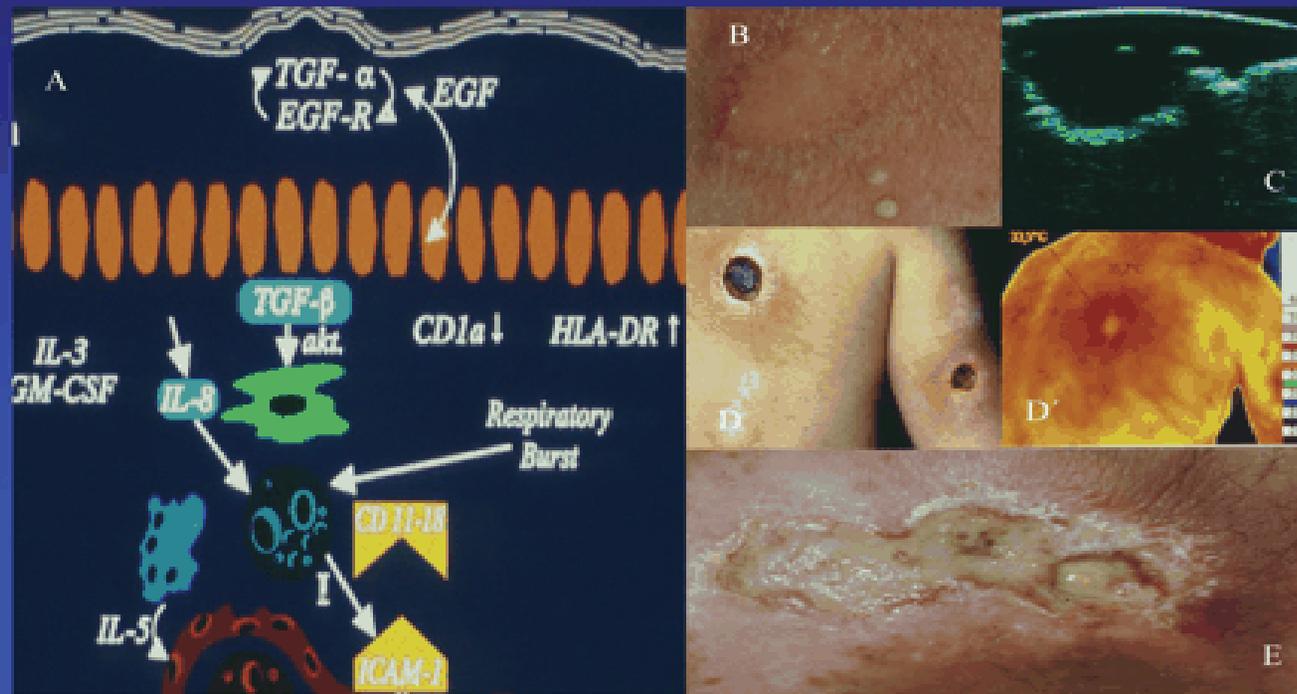
# Early and Late Skin Lesions in Radiation-exposed Patients after the Chernobyl Accident

ARS (Grade)	Number of patients	Body area	Early skin lesions (1986)	Late skin lesions	Basal Cell Carcinoma (BCC)
<b>I</b>	<b>5</b>	feet, LE, trunk, hands	Erythema, edema	Atrophy, pigment alteration, xerosis	
<b>II</b>	<b>6</b>	LE, UE, trunk + LE	Erythema, edema	Atrophy, pigment alteration, xerosis, keratosis, ulcers	
<b>III</b>	<b>9</b>	Combinations of the above	Erythema, edema, blisters, ulcers	Atrophy, pigment alteration, fibrosis keratosis, ulcers	
<b>IV</b>	<b>1</b>	trunk + extremities	Blisters, ulcers	Same as Grade III plus carcinomas	2 BCC lesions
<b>Non-confirmed group</b>	<b>1</b>				
<b>TOTAL</b>	<b>22</b>				

# Clinical appearance of CRS (Radiation Accident in Georgia, 1997)

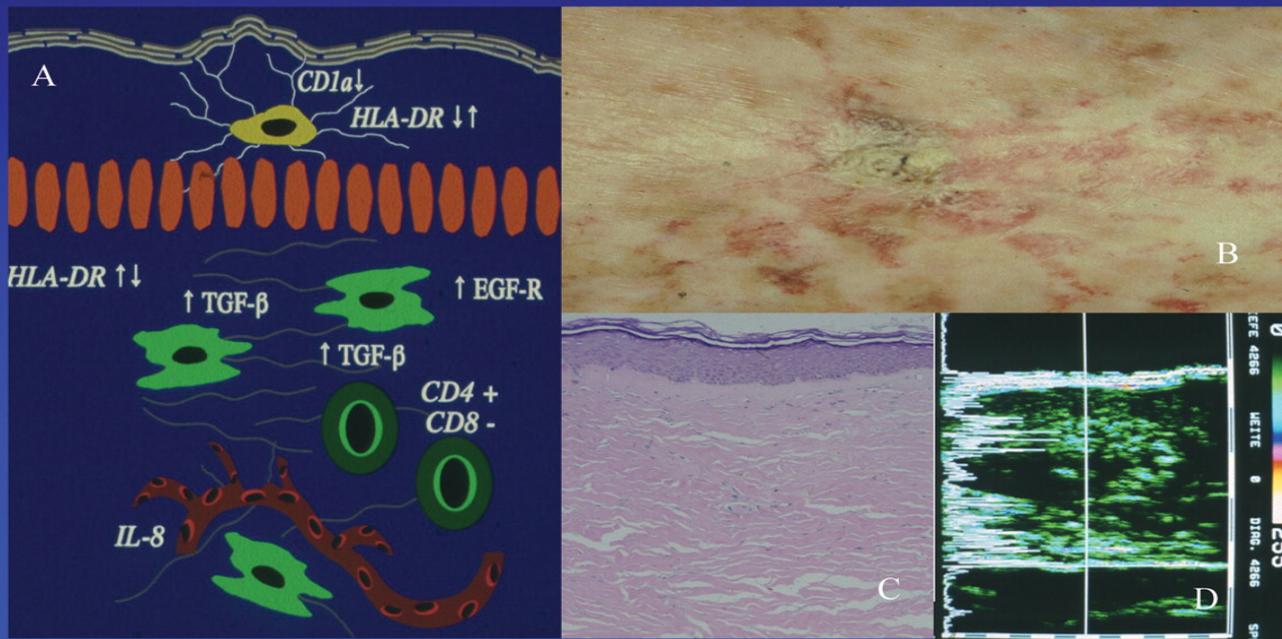
## Manifestational stage of CRS

24 hrs – 6 weeks



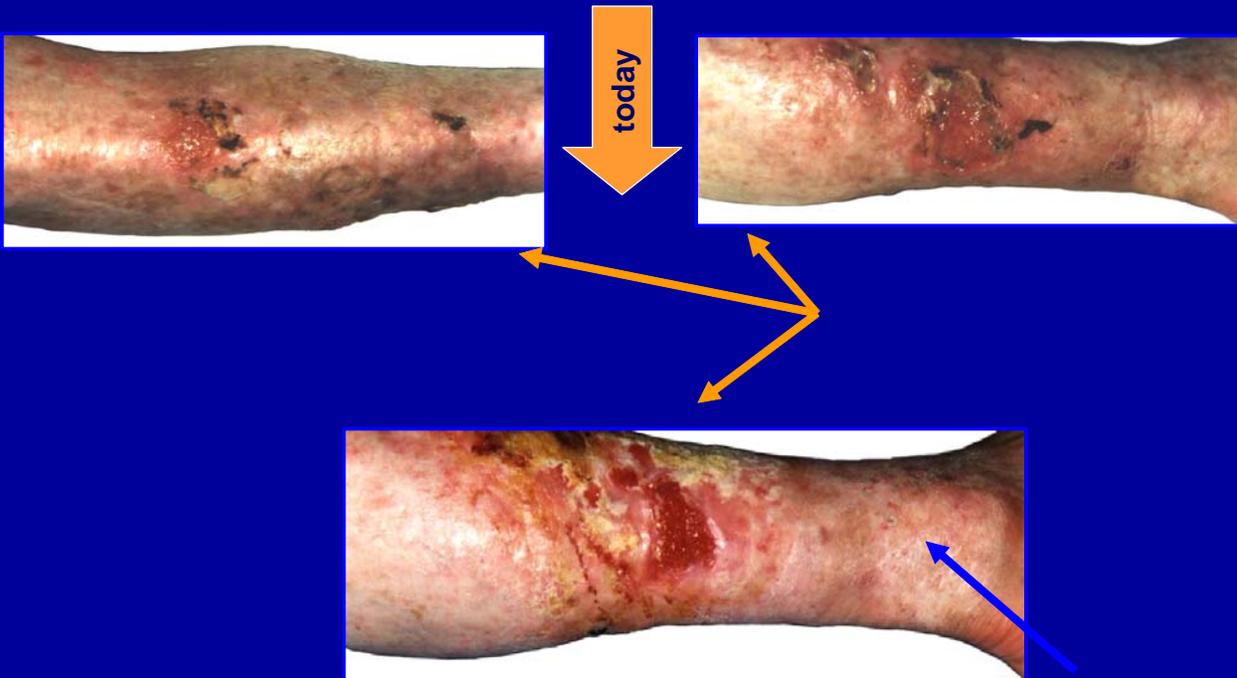
# Clinical appearance of CRS in Chernobyl Survivor, 1993

## Chronic stage of CRS 6 months – several years



# Delayed Effects of Accidental Cutaneous Radiation Exposure

## Severe Radiation Skin Damage



# Treatment Experience of Skin Injuries in Chernobyl victims

- **Systemic treatment**

*Hemoperfusion, plasmapheresis, continuous heparinization and administration of freshly frozen plasma*

- **Local treatment**

*Use of Combutec-2 for local treatment of skin injuries  
Aerosol Lioxanol  
Solution Balis-2*

- **Pain management**

*was challenging and not effective due to an absence of the local anesthetics in the treatment arsenal*

- **Necessity of surgical operations at an early stage**

*Guskova et al, 1988, Baranov et al, 1991, Selezneva, 1990, Barabanova, 2006*

# Causes of death among ARS survivors (1986 through 2006)

Cause of death	Grade I ARS	Grade II ARS	Grade III ARS	Total
Oncological and oncohematological pathology	1	2	2	5
Sudden cardiac death	2	2	2	6
Internal organ systems and neurological diseases	1	3	1	5
Traumas and accidents	2	-	-	2
<b>TOTAL</b>	<b>6</b>	<b>7</b>	<b>5</b>	<b>18</b>

# Current Diagnostic Principles of CRS

- 7.5 – 20 MHz B-scan sonography
- Thermography
- Capillary microscopy
- MRI
- Bone scintigraphy
- Histology

# Current Conservative Treatment of CRS

Stage	Treatment
<b>Prodromal</b>	Linoleic creams, steroids, antihistamine (Loratadine)
<b>Manifestation</b>	Topical/systemic steroids, hydrocolloid dressings, antibiotic prophylaxis, analgesics, $\gamma$ -interferon, thrombocytic subacute stage growth factors
<b>Chronic</b>	Basic therapy with linoleic acid, topical/systemic steroids, systemic application of pentoxiphylline and $\alpha$ -tocopherol, $\gamma$ -interferon hydrocolloid dressings, thrombocytic growth factors, semisynthetic dressing (Integra), analgesics
<b>Late</b>	Same as for the chronic stage

*R. Peter, Management of Cutaneous Radiation Injuries: Diagnostic and Therapeutic Principles of the Cutaneous Radiation Syndrome. Military Medicine, 167, Suppl. 1:100. 2002. 110-112.*

# Lessons Learned: Twenty years of Follow-up after the Chernobyl Accident (1)

- Cutaneous component of the ARS had significantly complicated the clinical prognosis and contributed to or caused death in patients
- Severe beta-burns of the skin remain an unsolved problem as a result of their spreading
- The severity of the skin damage could have been avoided by removing the contaminated clothing
- The prevention of late skin effects depends upon the effective management of acute lesions

## Lessons Learned: Twenty years of Follow-up after the Chernobyl Accident (2)

- The outcomes and late effects of the skin lesions depended on the depth-dose distribution and on the size of the area affected
- Radiation induced fibrosis is a predominant clinical problem
- Appearance of secondary ulcerations presents treatment challenges
- No malignant melanoma or squamous cell carcinoma have been detected so far

## What was the most unexpected for us?

- Diversity of clinical manifestations of skin lesions
- Unaccustomed course of clinical phases of a radiation injury to skin
- Significant severity of injuries
- Serious influence of skin burns on the general state of a patient
- Need for surgical interventions at an early stage