

David J. Baker

Toxic Trauma

A Basic Clinical Guide

Second Edition

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This book is dedicated to all those who have suffered toxic trauma and to those who have cared for them, in war and in peace.

Foreword

One of the most testing problems an emergency physician or clinical toxicologist can face is posed by a seriously ill or unconscious patient who appears to have been exposed to some toxic substance and whose clinical condition is rapidly worsening. Whether the identity of the substance is known from the clinical history or circumstances of exposure, or is unknown, it is likely that immediate treatment to support vital physiological functions will be needed. Contrary to popular opinion, specific antidotes are few in number and, in any case, cannot be given until the identity of the toxic substance, or substances, has been discovered. This may take some time, and time is a luxury seldom enjoyed by the emergency physician. As soon as one steps outside the range of drugs and chemicals too often chosen by those with suicidal intent, the range of toxic substances to which the patient may have been exposed becomes vast and includes materials of animal, plant and bacterial origin in addition to the innumerable toxic chemicals produced by man. A special case of the latter is provided by radioactive materials. In addition, though of less immediate importance to the physician, exposure may have been accidental or may reflect not suicidal but homicidal intent. One example of homicidal intent is provided by a terrorist attack involving the release of toxic chemicals and exposure of the civilian population. The 1995 attack on the users of the Tokyo subway and the attack on civilians in Damascus in 2013 provide examples of such activity. Such incidents pose a further burden on the emergency physician: not one but many patients who may be critically ill as a result of exposure to an unknown chemical or chemicals may have to be dealt with simultaneously. That anybody should be deliberately exposed to toxic chemicals is appalling; that physicians should be ill-prepared to deal with the clinical consequences of such attacks would be irresponsible folly.

Dr. Baker has addressed these problems in this new edition of *Toxic Trauma*. He has developed and refined the concepts of supportive and specific therapy by defining a series of toxidromes (clinical syndromes associated with exposure to toxic substances) that characterise the effects of a number of groups of toxic materials. These toxidromes are, in my view very sensibly, defined in terms

of the pathophysiological effects of groups of chemicals: understanding the pathophysiology leads to rational therapy. He has gone beyond mere definition: he has produced clear and concise advice on clinical measures needed to deal with the effects of such groups of toxic materials. His thinking is based on his wide experience of clinical toxicology and on his special expertise in the field of the toxicology of chemical warfare agents. It is in the latter field that the problems of dealing with chemical casualties are met at their most acute, and lessons learnt in this field can hardly fail to be of importance when civilian casualties of terrorist attacks have to be treated, indeed they should be remembered when any patients exposed to toxic chemicals are treated.

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Preface to the Second Edition

The object of the first edition of this book was to provide practical guidance to emergency medical responders faced with the problem of managing casualties from chemical agents, either accidental or as an act of warfare or terrorism. This was placed within the framework of the concept of toxic trauma, which considers that injury to the body as a result of toxic exposure should be regarded as part of the whole spectrum of trauma, which includes both the blunt and penetrating forms of physical trauma.

This approach appears to have been well received by readers of the first edition, judging from reviews and personal feedback to the author. This new edition of *Toxic Trauma* follows essentially the same structure as the first, but a number of sections have been expanded and there is a new chapter, which considers the place of chemical agents as part of the chemical, biological, radiological and nuclear (CBRN) classification of hazards which are often termed 'weapons of mass destruction'. The CBRN grouping, the types of trauma caused and the necessary responses are often poorly understood by medical, paramedical and nursing personnel who are only infrequently required to deal with casualties from each of the CBRN hazards. In reality, CBRN agents, while having some common characteristics, cause trauma in very different ways which require an adapted medical response. Radiation injury and radioactivity, in particular, are not always well understood by emergency medical responders, and the new final chapter attempts to provide a simple introduction to fill this gap.

Since the appearance of the first edition, toxic trauma from deliberate exposure to chemical warfare agents has continued in the Syrian Civil War, causing many thousands of casualties. The fear of further use of chemical weapons by terrorist organisations continues, and thus readiness to deal with chemical casualties in the urban civil setting remains more important than ever. In industrial and domestic settings, the accidental release of toxic chemicals continues and no hospital department can afford not to prepare for such incidents, both in daily practice and as part of disaster-response planning. The hazards of toxic trauma remain therefore as real as ever, and I hope that the new edition of this book will help to inform and to prepare responses accordingly.

I would like to acknowledge colleagues who reviewed the first edition and provided many helpful comments, notably Dr. Samuel Delerme, Dr. Michael Nurok and Prof. Robert Maynard, who has kindly provided a foreword to the present edition. I would also like to thank the editorial team at Springer Verlag for all their help and support. Finally, I would like to thank my wife and colleague Dr. Marian Barry for her invaluable help with reading and correcting the proofs.

I hope that the new edition of *Toxic Trauma* will prove to be essentially practical and readable by the non-specialists for whom it is written and will encourage more interest in what has in the past been a rather remote area of practice for many.

Paris, France

David J. Baker

Preface to the First Edition

The past 30 years have seen the development of a rational and comprehensive approach to the management of physical trauma in response to a steady world-wide increase in the numbers of those injured in both peace and war. In civil emergency medicine, there has been increasing experience of the management of physical trauma from road traffic accidents, natural disasters such as earthquakes together with gunshot wounds and blast injury from terrorist improvised explosive devices, while continuing wars around the world have meant that a new generation of military medical personnel has had extensive experience of modern trauma management.

Systematic training courses such as the US College of Surgeons Advanced Trauma Life Support (ATLS™) and other national programmes have been developed and are widely taught around the world. Trauma management has become a standard part of the training of surgeons, emergency medical physicians, anaesthetists and other medical and paramedical specialities, and an early systematic approach has had considerable impact on the clinical outcome.

In contrast, the management of casualties following exposure to toxic chemicals has not received quite the same attention, although evidence shows that both military and civil pre-hospital and hospital medical personnel are increasingly likely to be required to treat such cases. In the civil setting, the risks are increasing, as is public awareness and fear of chemical exposure. Nearly a century after the first large-scale use of chemicals in warfare, the threat of chemical exposure still remains and has now been extended to deliberate release on civil populations by terrorists. In addition, accidental releases of toxic industrial chemicals have produced catastrophic consequences, particularly in developing countries where medical care may be limited.

The management of exposure to toxic chemicals goes beyond the relatively familiar emergency room situation of accidental or deliberate ingestion of poisons and requires a medical approach that ensures both a rapid and effective response for the patient and also protection of the responders against the secondary effects of the causative toxic agent to ensure they do not become casualties themselves. Accidental release of hazardous toxic materials (HAZMAT) is managed according

to international guidelines and, following the precedent set by physical trauma specialist, training courses such as the Advanced Hazmat Life Support Course (AHLSTTM) have been developed. However, participation in these and experience of the management of casualties of toxic releases are not as widespread as for physical trauma.

Individual poisoning is most familiar by ingestion but exposure to toxic chemicals, with entry to the body through other routes such as respiratory system and the skin, can potentially affect all the systems of the body. In addition, there are a number of identified pathways of pathophysiological damage that are convergent with those of conventional physical trauma. Respiratory and cardiac arrest together with organ failure may be a terminal event following both physical trauma and exposure to toxic chemicals, and in severe cases intensive care is required in both situations.

From the overall standpoint of injury management, the systematic medical management of exposure to toxic substances may be viewed as part of a spectrum of the various forms of physical trauma and which may be termed 'toxic trauma'. The management of toxic trauma goes beyond the conventional clinical toxicological management of ingested poisoning and links together other specialities who are individually concerned with the management of toxic effects on specific body systems, notably neurological, respiratory, cardiac, ophthalmological and dermal. In addition, the concept of toxic trauma, rather than poisoning *per se*, serves to underline the potential danger to medical responders from the same toxic substance that has caused the primary injuries which is not often a problem in the emergency room following poisoning by ingestion or envenomation.

There is a widely held view among the general public that injuries from the mass release of chemical agents, which are often regarded as being 'weapons of mass destruction', cannot be treated and will be inevitably fatal. This has given rise to a fear of chemical exposure which is out of proportion to the potential injury. A positive approach by medical professionals and the integration of the management of toxic trauma into other trauma management will do much to restore public confidence and order in the event of a terrorist attack or other toxic release with the realisation that while chemical agents may cause mass injuries, these can be prevented or treated with a prepared and coordinated medical response.

The object of this book was to provide a basic understanding and practical guidance to emergency personnel and others faced with the possibly unfamiliar situation of having to manage individual or mass chemical casualties as part of their work in a civilian ambulance service or hospital. The text will consider the nature of the hazards faced and the practical management of persons exposed to chemicals and to toxins (which although of biological origin behave as chemicals in terms of their effects and transmission).

The individual chapters will consider the development and classification of chemical toxic agents, how exposure can occur and how medical personnel should be involved in its management. Subsequent sections consider the nature of toxic

trauma and the pathophysiology processes involved, together with a systematic approach to early and continuing management. In addition, examples of incidents are presented. The aim of this guide is to help emergency medical and paramedical personnel become familiar not only with the management of the victims but also how to operate safely within potentially contaminated areas to prevent them also becoming secondary casualties from a chemical release.

World wide, there is a continuing risk of exposure to chemical agents from both accidental industrial discharges and deliberate release of chemical warfare agents and toxins as part of chemical warfare or terrorist activity. In the military and terrorist contexts, chemical agents are grouped together with biological, radiological (radioisotopes) and nuclear weapons (CBRN) in terms of management. In practice, however, the management of chemical exposure is very different from the management of infection with biological agents and exposure to radiation. Thus, the management of biological, radiological and nuclear explosive exposure will not be considered in this text. These can cause physical trauma and systemic effects, but the management of infection and radiation injury is the subject of many specialised texts. There are also many detailed clinical toxicological texts available concerning the management of individual poisoning which this book will not attempt to duplicate.

The literature about exposure to toxic chemicals in peace and war is vast and usually too detailed for the reading time available to busy emergency medical responders. Equally, there are a number of short guides to the management of hazardous materials releases which do not explain the pathophysiology and most importantly the details of life support measures and specific therapy from the standpoint of a trained physician. To attempt to bridge this gap, each of the following chapters provides a synopsis of the current thinking, concerning the nature and management of toxic trauma based upon detailed published information in specialised texts and the author's personal experience over a number of years in the field. A selection of suggestions for further reading is provided for each section which will provide further detailed information for those requiring it. Specific referencing of the text has been avoided for simplicity of reading. However, the suggestions for further reading have been selected because the texts contain lists of essential references from a wide range of medical and scientific fields that have provided the basis of our knowledge about the effects of chemical exposure.

In particular, I have drawn upon the detailed and authoritative volume on chemical warfare agents which is a part of the continuing series of publications that forms the monumental US Army Textbook of Military Medicine. This and other more specialised texts will perhaps be beyond the reading time available to non-specialists, and I hope that my distillation of information will be accurate and appropriate.

The object of this book was to provide a concise clinical guide to the nature and management of toxic trauma which can be used to aid preparation and responses to releases of chemical agents. Hopefully, it will help to promote confidence and a

positive approach to chemical casualty management among those who find themselves in what may be an unfamiliar situation with possibly little or no advance warning and will promote an integration of toxic trauma into a comprehensive approach to the overall management of trauma.

David J. Baker

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