

ENDEMIC ARSENICOSIS

A Clinical Diagnostic Manual with Photo Illustrations

Sino-English bilingual version

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Photographers : Zhai Ruodong
: Shi Songtian

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A Clinical Diagnostic Manual with Photo Illustrations

Sino-English bilingual version

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About This Manual

This manual has been prepared to serve as a reference resource for medical officers, health workers and programme officers to use for clinical diagnosis of arsenicosis caused by chronic arsenic poisoning from drinking water or contaminated food due to coal burning. It also is intended for use in the training of medical professionals and health workers.

This manual is the first publication on clinical diagnosis of skin lesions of arsenicosis. Medical professionals have yet to establish a clear case definition of arsenicosis. However, a group of arsenicosis experts in the People's Republic of China developed guidelines for clinical identification based on their decades of field experiences dealing with chronic arsenic poisoning. China's Ministry of Health recently approved those guidelines.

Adopting the Chinese classification, this manual presents symptoms of skin lesions of arsenicosis, along with photos to illustrate its stage-by-stage manifestation, that are based on cases in affected areas in China. Some variation of symptoms between areas does occur. For instance, "black foot disease" is associated with the consumption of drinking water containing high levels of arsenic and humic substances having fluorescent matter but was found only in Taiwan province in

the 1950s. So far, it has not been identified in any other affected area in China. (This manual does not include symptoms of black foot disease.) Generally, however, skin lesions of arsenicosis in the forms of hyperkeratosis, hyper-pigmentation and hypo-pigmentation commonly are diagnosed in patients suffering from chronic arsenic poisoning due to the consumption of water, food or inhaling air containing high levels of arsenic. It is these symptoms that are the focus of this manual.

For readers' convenience, this manual has been published in separate English and Chinese versions.

Structure of the manual

Part I presents the situations of endemic chronic arsenic poisoning in China and the Chinese Government's actions on prevention, management and mitigation of chronic arsenic poisoning. Part II introduces the key points of the *Chinese Guidelines for the Clinical Diagnosis of Arsenicosis*. Part III illustrates, in photos, the stage-by-stage manifestations of hyperkeratosis, hyper-pigmentation and hypo-pigmentation caused by arsenicosis, based on the Chinese government-approved guidelines for clinical diagnosis.

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Sun Guifan

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Preface

Sporadic incidence in the People's Republic of China of endemic chronic arsenic poisoning, resulting in the manifestation of arsenicosis, dates back to the early 1950s in Guizhou province. That prevalence was related to the coal-burning contamination of dried food. However, awareness of the problem was not raised until the incidence of chronic arsenic poisoning, caused by natural occurrence of arsenic contamination in groundwater as drinking water source, was reported in Taiwan province shortly after. That incidence was associated with the so-called "black foot disease", which never has been found elsewhere in China.

Chronic arsenic poisoning in extensive areas in Asia emerged in the 1980s. It was first reported in the late 1970s in China's Xinjiang autonomous region and was caused by the consumption of arsenic-contaminated drinking water from artesian wells and tube wells fitted with hand pumps, with resulting skin lesions clinically evident. And yet, those reports failed to raise broad public awareness beyond China, perhaps because they were published in Chinese. As well, arsenicosis (caused by drinking water containing high levels of arsenic) was diagnosed in such provinces/autonomous regions as Inner Mongolia, Shanxi and Jilin of China and in West Bengal, India. Global awareness came about in the 1990s only when widespread endemic chronic arsenic poisoning in Bangladesh was reported (caused by drinking naturally arsenic-contaminated water from tube wells fitted with hand pumps). Meanwhile, food-related arsenicosis caused by the burning of arsenic-rich coal was gradually spreading in pocket areas in China's Guizhou and Shaanxi provinces.

Owing to the vigorously promoted and implemented tube well with hand pump that gained wide popularity in certain countries, especially in rural areas of developing nations, more and more cases of well water with high levels of arsenic content have been detected since the 1950s.

The scope of people threatened by arsenicosis continues to increase. An estimation of tens of millions of people drinks arsenic-contaminated water in Asia and thus undergoes prolonged exposure to the dangers. The number of people diagnosed with poisoning symptoms has amounted to hundreds of thousands, of which the majority is women and children. Since arsenic, a highly poisonous element, is a classified carcinogen, it poses a great health implication to those who have been suffering from chronic effects of prolonged exposure and to those who are living in the high-risk areas.

Arsenic is a common element in the earth's crust. It imposes a health hazard when it leaches out of the soil into groundwater. Despite being an emerging health crisis in the twenty-first century, currently no one knows for certain how arsenic poisoning develops in the human body and what is the best way to treat it.

Furthermore, the magnitude of arsenic contamination of groundwater in the countries affected and would be-affected in the region is not known. The effective strategies adopted in China to tackle chronic arsenic poisoning, therefore, are twofold: First, early detection of arsenic-tainted wells as a preventive measure is key. In areas of high levels of arsenic-contaminated well water, the adoption of appropriate technologies and/or harvesting

the rain and snow to provide the alternative arsenic-safe supply of water are effective measures for mitigating chronic arsenic poisoning. As to the endemic areas where coal burning pollutes food and air, efforts should be made to replace the conventional kitchen stoves and to promote the use of coal that has low levels of arsenic. Second, health screening of inhabitants in risk areas of short- and long-term exposures should be conducted in order to make diagnosis of arsenic poisoning early and to treat as best as possible (because no one knows how to treat, the most that can be done for now is to apply an ointment for hyperkeratosis).

It is with concerns for prevention that we set about compiling this photo manual.

There does not seem to be any widely accepted diagnostic guidelines of chronic arsenic poisoning. Subsequent to the detection of endemic chronic arsenic poisoning in extensive areas in China, Chinese specialists in arsenic research, clinicians, epidemiologists and toxicologists joined forces and visited those areas where the incidence was reported. In conducting their research and diagnoses, they accumulated a treasure chest of clinical experience. With support and coordination from the Ministry of Health in 1998, these experts developed guidelines on diagnosis of endemic arsenicosis to be used in affected areas. Those guidelines have proven to be an important tool and reference in the early diagnosis of arsenicosis and were approved in 2003 by the Ministry of Health.

As shown in the clinical manifestations of arsenicosis patients in China, long term ingestion of high levels of arsenic can create

a battery of symptoms and manifestations involving various organs, including cancer. However, it is skin lesions that are most prominent and therefore observationally distinguishable. Also, skin lesions induced by arsenicosis tend to emerge at a relatively early stage and are of such specificity they make for easy examination and diagnosis. Thus, the Chinese diagnostic guidelines for arsenicosis are based upon symptoms of skin lesion manifestations, with laboratory bio-test results used as diagnostic aids. Pictures shown in this manual have been compiled accordingly to serve as the guiding principles and tool for professionals and workers engaged in diagnosis and controlling endemic arsenicosis and for personnel conducting surveys of the prevalence of chronic arsenic poisoning in endemic and at-risk areas.

The illustrations included here have been culled meticulously from several hundred photographs taken during recent years of intensive fieldwork in the endemic areas of arsenicosis. In the process, we have been generously supported by local endemic disease institutes in the provinces/autonomous regions of Shanxi, Inner Mongolia, Xinjiang, Jilin, and Guizhou and by the willing cooperation of arsenicosis patients.

The general objective of this manual is to briefly introduce the situation of endemic chronic arsenic poisoning in China and some actions taken by the Chinese Government, with support from UNICEF, on its prevention and mitigation. The specific objective is to illustrate through photos in a detailed, stage-by-stage manner the various degrees of symptoms of arsenicosis in the affected areas of China. The material presented here

is based on field experience of more than 20 years, accumulated by scores of medical professionals who have developed and used the *Chinese Guidelines for the Clinical Diagnosis of Arsenicosis* in dealing with chronic arsenic poisoning. It is our aim to provide medical professionals and health

workers in the affected countries with a reference and training tool – the first pictorial publication on symptoms of arsenicosis.

We cordially welcome practical suggestions from our readers for a possible future edition.

Sun Guifan

October 2004

"Access to safe water is a fundamental human need and, therefore, a basic human right. Contaminated water jeopardizes both the physical and social health of all people. It is an affront to human dignity."

**Kofi Annan,
United Nations Secretary-General.**

Endemic Chronic Arsenic Poisoning in China

1. Overview of the situation in Asia

Endemic chronic arsenic poisoning is a new and growing public health problem that now affects millions of people and children in Asia. Drinking arsenic-contaminated groundwater or eating food that has been dried by burning arsenic-rich coal causes chronic arsenic poisoning. And long-term consumption of high levels of arsenic can result in arsenicosis, which manifests as skin lesions of hyper-pigmentation, hypo-pigmentation and hyperkeratosis, and eventually leads to cancer and death. The poisoning occurs after the arsenic slowly accumulates in organ tissue. Although previously believed to affect only adults, clinical arsenicosis now has been diagnosed in children as young as 6-18 months of age. And children have proven to be especially susceptible to the harmful impacts.

Because of its pervasive effect on all systems in the body, arsenic toxicity has complex and far-reaching consequences on the developing child, such as cognitive delays, reduced IQ, mental slowing and poor memory – all of which deny the child the "best start in life".

The effect on the child *in-utero* is the subject of ongoing research, with indications that arsenic may be transmitted from mother to child. There is no known medical cure so far for arsenicosis or any workable ways and means to alleviate its long-term harmful effects on human beings. The only sure way of preventing the disease is to cut off the intake of arsenic – stop people from drinking contaminated water or consuming contaminated dried food.

Arsenic contamination of groundwater occurs naturally and has been detected in the tube well / hand pump drinking water supply in Bangladesh, Cambodia, China, India, Lao PDR, Mongolia, Myanmar, Nepal, Pakistan and Viet Nam (Figure 1, 2). It is estimated that about 200 million people are at risk of harmful toxic effects in these countries. Currently, tens of thousands of people in Bangladesh, China and India have been diagnosed with arsenicosis. And efforts are being taken to identify the affliction in the other affected countries. Meanwhile, tens of millions of inhabitants, mostly in rural areas, continue to drink the arsenic-contaminated water every day. The governments in these countries lack



Figure 1: Asian countries affected by arsenic contamination of drinking water and dried Food (through burning coal having high arsenic content)



Figure 2: Arsenic-contaminated groundwater in a household tube well with hand pump, Bangladesh

financial capabilities to provide the alternative arsenic-safe water supply to the affected populations.

The burning of coal containing high levels of arsenic – and fluoride – for cooking, heating and drying food has caused contamination, which has resulted in chronic arsenic and fluoride poisoning (and thus arsenicosis and fluorosis). So far in China, however, two provinces and other pocket localities have been affected; with poor, rural families hit the hardest.

2. Background of endemic chronic arsenic poisoning in China

Chronic arsenic poisoning in China has resulted in endemic arsenicosis in vast areas, much of it rural. It was first observed in the 1950s and then in the late 1970s and early 1980s in various localities. Chronic arsenic poisoning in China can be classified into two types, based on the source: **drinking water type**, which is due to the consumption of groundwater in medium and deep wells containing high levels of arsenic, and **coal-burning type**, caused by the consumption of foods (corn and hot peppers) that have been dried by burning coal containing high levels of arsenic in open stove. In these areas, the arsenic-contaminated coal also is burned for cooking and heating and thus pollutes air within the homes.

Drinking water type

The chronic arsenic poisoning was reported in Taiwan province in the 1950s. But that incidence was associated with the so-called "black foot disease" and seems to have been restricted to Taiwan province only.

In the late 1970s and early 1980s, arsenic-specific coetaneous changes were diagnosed in Xinjiang autonomous region and subsequently in Inner Mongolia autonomous region and Shanxi province. Recently, endemic arsenicosis was also found in Jilin, Ningxia, Qinghai and Anhui provinces.

Gradually, more wells having high levels of arsenic were detected in other provinces, followed by an increase of arsenicosis among people in those areas. Currently, more than 3 million people remain at risk, while more than 10,000 arsenicosis cases have been confirmed. The Chinese government set a health standard for arsenic content in water at 50 ppb. Arsenic in the well water in the affected provinces and autonomous regions has measured in the range of >50-1860 ppb (1). Long-term consumption of highly contaminated water (from both drinking and cooking with it) will result in chronic arsenic poisoning and eventually arsenicosis and leading to cancer and death.

Exposure to high levels of arsenic in the drinking water has been attributed to the gradual improvement of living standards in rural China. Since the economic reforms began in 1978, many peasants have been able to afford drilling medium-deep wells (20-30 m) fitted with hand pumps at their home and village schools (Figure3, 4) rather than use the highly saline, bitter and astringent or fluoride-rich water from the traditional



Figure 3: Arsenic-contaminated water in a school tube well with hand pump, China



Figure 4: Arsenic-contaminated water in a household tube well with hand pump, China

shallow wells or surface water. Medium-deep wells provide microbiologically safe water, thus help control water-borne diseases. In addition, it is convenient and energy saving – rather than having to collect it from afar. However, wells of 20-30 m are mostly tapping water from arsenic-rich aquifers. Thus the convenience, unfortunately, has exposed a large sector of the rural population to chronic arsenic poisoning over the past couple of decades.

Coal-burning type

The coal-burning type of chronic arsenic poisoning occurs mostly in south-western China. It is caused by burning coal containing high levels of arsenic in an open stove in the house. The first patient was diagnosed in 1953 in Guizhou province, but not until the 1980s were more patients identified. Coal became more popularly used when local governments opened small coal mines to the public over the years to freely excavate for use in cooking and heating the home. It also was used for drying harvested corn and peppers as a means of preservation, needed due to the extremely high ambient air humidity during the harvest season. The coal from these mines generally contains high levels of arsenic and fluoride. For instance, in Guizhou the arsenic found in coal has measured in the range of 826-3,360.9 mg/kg (2), with the highest content at 9,600 mg/kg (3). For comparison, the arsenic content in samples of coal from 110 mines elsewhere in 24 provinces in China ranged from 0.32 to 119 mg/kg (4).

As the harvest season in this part of China is normally damp and wet, corn and peppers should be dried prior to storage. As a result, both the indoor air and the dried corn and peppers are contaminated with arsenic that is released when the coals are burned in the open stove. The arsenic concentration in the indoor air has been found at levels of 20-400 ug/cu m (5). The government standard for arsenic content in indoor air is 3 ug/cu m. The arsenic levels in the dried corn in the affected areas in Guizhou were reported at 5.28-24.96 mg/kg compared to that of the fresh corn in

the same affected area of 0.34-0.58 mg/kg (1). The arsenic content in the dried peppers has been found as high as 236.3-846.1 mg/kg, while arsenic in the fresh peppers has measured from 1.06 to 3.58 mg/kg (1).

Residents in these areas widely use the local coal that has high levels of arsenic and fluoride in their open stove inside their house without a chimney (Figures 5,6,7).

The indoor air, therefore, is contaminated with



Figure 5: Rural family keeps warm near a conventional coal-burning open stove; the burning of the high arsenic coal releases arsenic and contaminates the air, Guizhou province, China



Figure 6: Hot peppers dried over a conventional open stove in a rural household kitchen; the peppers adsorbed/absorbed arsenic released by the burning of high arsenic coal during the drying process, Guizhou province, China



Figure 7: Corn dried over a conventional open stove in a rural household kitchen; the corn adsorbs/absorbs arsenic released by burning of high arsenic coal during the drying process, Guizhou province, China

high concentrations of arsenic and fluoride. As people thus both consume affected food and inhale contaminated air, a widespread incidence of arsenicosis and fluorosis occurs among the villagers. Whether the presence of high levels of fluoride in the dried food enhances the manifestation of arsenicosis, or vice-versa, is unknown and research studies need to be carried out.¹ Endemic coal-burning arsenicosis has spread to five counties in Guizhou province and in some counties in Shaanxi province (1).

Because people both inhale a high degree of arsenic in the indoor air and ingest high arsenic contaminated food, the symptoms of arsenicosis and the harmful effects to the body caused by coal-burning type are much more severe than those caused by the drinking water type (6).

Inner Mongolia, Shanxi, Jilin, Ningxia, Quinghai, Anhui, Guizhou and Shaanxi (the latter two provinces with only the incidence of coal-burning type), as shown in Figure 8.

The magnitude and the scale of the problems in the affected areas are still not fully known, and yet new endemic areas are continuously emerging. It is expected that more and more cases of arsenicosis will be diagnosed in these provinces. As mentioned, more than 3 million people are at risk of developing arsenicosis from their drinking water and another more than 300,000 people risk it from eating contaminated dried food and inhaling polluted indoor air. More than 10,000 confirmed arsenicosis patients have been identified, but more and more cases are expected. Epidemiological information on arsenicosis patients in most areas is still unavailable. What

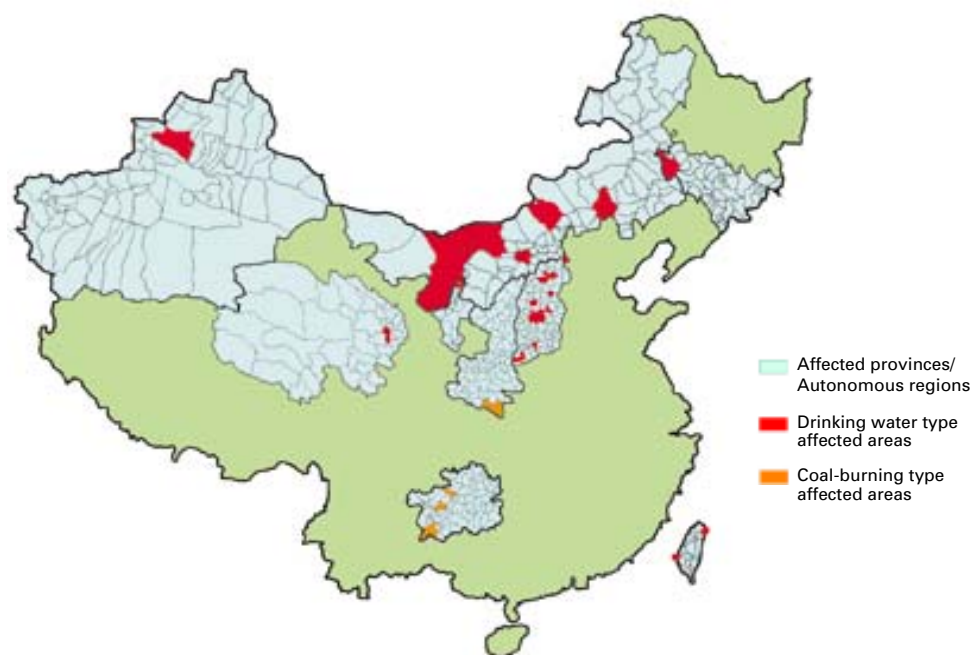


Figure 8: Provinces and autonomous regions affected by the drinking water type and coal-burning type of chronic arsenic poisoning, China (2004 data)

3. Current situation of endemic chronic arsenic poisoning in China

The current problem of chronic arsenic poisoning resulting in endemic arsenicosis in China is considered a grave public health problem. The affected provinces and autonomous regions found so far are Xinjiang,

has been reported is considered only the tip of the iceberg. There is an urgent need for the Government to investigate the extent of endemic chronic arsenic poisoning in China for in-depth understanding of the magnitude of the problem and for effective prevention and management of this silent public health calamity.

¹ This manual deals with chronic arsenic poisoning only.

The situation in the affected provinces and autonomous regions, based on surveys, investigations and research studies carried out by various government agencies, are summarized as follows:

Drinking water type

Xinjiang autonomous region

Xinjiang is the first region defined as an endemic arsenicosis area in China. The affected area lies in the southwest of Zhungaer Basin, where it winds its way from the west of Aibi Lake to the east of Manasi River and covers 250 km of terrain where the groundwater is rich in arsenic. The affected areas are in a valley where endemic chronic arsenic poisoning is found in the lowest land that is arid but rich in deep groundwater aquifers. Prior to 1962, residents mainly used the shallow-well water and surface water for their household needs. But after the early 1960s, many deep wells (more than 100 m deep) were drilled to supply water for domestic consumption and agricultural purposes. Arsenic concentration higher than the government standard of 50 ppb in the well water was not detected until almost a decade later. The concentration of arsenic in these deep wells was found to increase as the land altitude decreased in relation to sea level.

The concentration of arsenic has measured as high as 600-850 ppb in some newly developed areas of Wusu county (4). The population at risk is estimated at more than 100,000 people, with more than 2,000 cases of arsenicosis already confirmed. The incidence of disease has shown to increase with the increase of arsenic concentration in the drinking water. In certain severely affected areas where the arsenic level in water has measured 750 ppb, the incidence of disease is as high as 46.4 percent (4). The arsenic mitigation programme of providing the permanent arsenic-safe water piped supplies have been implemented in certain affected areas with the strong support of local government and the joint efforts of the Xinjiang Endemic Disease Working Group.

Currently, many wells are still in need of testing and the provision of arsenic-safe water supplies also is urgently needed.

Inner Mongolia autonomous region

The Ministry of Health in 1989 categorized Inner Mongolia as another severely endemic arsenicosis area in China. Affected areas have been pinpointed to an eastern section of Chifeng city where an arsenic-rich mine has polluted the well water and in the western portion of the region where groundwater is rich in natural arsenic. The western endemic area is a strip of land located in an alluvium plain that links with the northern endemic area of Shanxi province. In Inner Mongolia, the areas of high arsenic levels cover about 3,000 sq km with over 1 million people at risk, affecting about 400,000 people, with nearly 3,000 confirmed arsenicosis patients diagnosed in 776 villages of the five cities of Chifeng, Baotou, Huhhort, Bayandaer and Alashan (1). The highest arsenic level in the affected areas in Inner Mongolia is reported, so far, as 1860 ppb.(1) Arsenicosis in Inner Mongolia is characterized by a high incidence and severe symptoms that deteriorate rapidly (4). There is also a high incidence of cancer in Tiemengeng and Heihe villages of Huhhort, where the residents have been exposed to high levels of arsenic in drinking water for more than three decades. The long-term carcinogenic impact of arsenic is obvious here. At present, many risk areas are still without arsenic-safe drinking water. Moreover, an all-round testing of the arsenic level in wells and diagnosing arsenicosis among inhabitants have yet to be conducted. It is most likely that many risk areas and arsenicosis patients remain unreported.

Shanxi province

After the Ministry of Health defined the drinking water-type arsenicosis as an endemic disease in 1994, a large high arsenic area was detected in the Datong Basin of Shanxi province in June of that year. The area was officially defined as an endemic arsenicosis area. Another high arsenic belt was found in

the Jinzhong Basin during investigation of the disease in the following December. These two high arsenic belts cover 129 villages of 10 counties in Datong city and Taiyuan city and extend over 1,500 sq km, with near one million people at risk of arsenicosis and more than 4,000 cases already confirmed (1). Although the exposure time for the residents in these areas is relatively short, more severe cases of arsenicosis have been found among the population at risk compared with those in other areas. This may be attributed to the consumption of well water of much higher arsenic concentration at 783 ppb (1). Several arsenic-safe piped water supplies have been provided to certain arsenic affected areas so far, but many people in the endemic spots still are drinking high arsenic water.

Jilin province

The affected areas are found in the west plane of Jilin province. Currently the endemic areas are found in 67 villages in four townships of Tongyu and Taonan Counties where 26 percent of groundwater had an arsenic concentration exceeding the government standard of 50 ppb, with the highest level measuring 207 ppb (1). The population at risk is about 60,000; there are 670 confirmed arsenicosis patients.

Ningxia province

The affected areas are reported in 22 villages in three townships of Pinglo and Weiyi counties, which are located in the north part of the province along Holan Mountain. The concentration of arsenic in well water there was reported to range from 106 ppb to near 2,000 ppb (1). About 25,000 people are affected and currently there are about 500 confirmed patients.

Qinghai province

Qinghai province also has been classified recently as another risk area, but detailed information is not yet available. The populations at risk, the number of arsenicosis cases and the arsenic levels in well water are being under investigated.

Taiwan province

In the 1950s, a disease similar to thromboangiitis obliterans and known as "black foot disease" prevailed among inhabitants of Beimen and Yizhu villages on the south-western coast of Taiwan province. Arsenic concentration in deep well water (100-280 m) there measured at 240-1800 ppb. Researchers concluded that sulphide oxidation in terrain that was rich in sulphide-bearing arsenic minerals had contaminated the water (4). The well water also contained humic substance with fluorescent matter. People affected experienced numbing and immense pain in their limbs, particularly the lower limbs. The skin blackened, hence the affliction became widely known as "black foot disease". Gangrene typically developed as well. At the time, some medical researchers in Taiwan province believed that the disease was due to chronic arsenic poisoning, others thought it was the combined effects of high levels of arsenic and humic substance with fluorescent matter (7). The disease slowly spread from a person's lower limbs toward the body's trunk. Deteriorated gangrene and severe pain tended to be so unbearable that some patients committed suicide, which brought about a wide degree of attention. An arsenic-safe water supply then was provided to the affected areas in Taiwan in the 1960s. No new case of "black foot disease" has been detected among any person born after that time. However, "black foot disease" has been diagnosed in some older inhabitants who had consumed well water containing high levels of arsenic and humic substance prior to the provision of arsenic-safe water. This implies possible long-term harmful effects of arsenic in the human body even after stop intake of arsenic (4). Interestingly, black foot disease was detected only in Taiwan province and not in any of the arsenic-affected areas elsewhere in China and in other arsenic poisoning countries so far.

Coal-burning type

Guizhou province

Endemic arsenicosis in Guizhou province in southern China is chiefly caused by

consumption of highly contaminated dried staple food and inhaling contaminated indoor air. Some 126 villages in eight townships in Xingren, Xingyi, Anlong, Kaiyang and Zhijin counties, situated in the western part of the province, have been classified as endemic areas. About 300,000 people are at risk and more than 3,000 cases of arsenicosis have been diagnosed. The climate of the affected areas is damp and cold and therefore heating is needed four to five months annually. The local practice for cooking and heating is to burn coal, which contains high levels of arsenic and fluoride, in open stoves. And because of dampness during the rainy harvest season, it is difficult for the grains to dry at ambient temperature, thus open-coal fire is typically used to dry the harvested corn and peppers, the local staple food.

Concerned government agencies have issued some measures to prevent the use of arsenic-rich coal. Action has been initiated to promote improved stoves (closed stove with chimney to vent the arsenic-rich fume) as the major mitigation measure as well as social education on thoroughly washing the dried corn and pepper prior to cooking to reduce the arsenic concentration. However, the effective implementation of mitigating measures requires intensive social mobilization to encourage people to change their behaviour.

The arsenic content in coal in different areas or coal mines tends to vary considerably and often, even within the same mine. Such variation of arsenic levels in coal used by locals complicates the already complex problems of the spreading and patterns of diseases. In all affected areas where open stoves are used to dry corn and hot peppers, people should be made aware of the need to vigilantly guard against the harmful effects of chronic arsenic poisoning. However, many affected areas are still not being investigated. A full-scale survey of coal burning-type arsenicosis, especially the epidemiological study on the severity of the disease, is therefore urgently needed. The outcome of such investigation could help to draw

effective preventive measures and social education in creating behaviour change among people to use the improved stoves.

Shaanxi province

Shaanxi province recently was reported as another risk area of coal-burning endemic chronic arsenic poisoning, the detailed investigation is being carried out.

4. Nature of endemic chronic arsenic poisoning in China

Distribution patterns of arsenic level in wells and in coal and arsenicosis patients

Endemic arsenicosis can affect only people who have been exposed to high levels of arsenic in their drinking water or contaminated dried foods over a certain length of time. Due to geological factors, both low and high levels of arsenic in groundwater used as a drinking water source are spreading sporadically in the affected areas. Some wells register quite high levels while others contain levels lower than the government standard of 50 ppb. In severely affected areas, more than 80 percent of wells contain a high degree of arsenic concentration. In the not-so-severely affected areas, about 5 percent of wells are detected high arsenic. In general, high arsenic concentrations are found in wells that are 20-30 m deep, and in some more than 50 m deep. In Huhort City of Inner Mongolia autonomous region, high arsenic concentrations have been detected in wells that are less than 10 m deep. Similarly, in the coal-burning endemic areas, not all of the families use the arsenic-rich coal. Hence, there is a scattered distribution pattern of arsenicosis patients in the affected areas relating to the distribution patterns of high/low arsenic levels in wells and in coal used. Such scattered patterns of arsenic contamination over vast areas complicate the action and financial input needed for prevention and mitigation.

Demographic features of patients

The following demographic features of arsenicosis patients are drawn from decades of studies, surveys and observations in China (4).

- (i) Almost all endemic areas are in rural areas and all patients are peasants, thus there are no differences in occupation.
- (ii) Anyone exposed to high levels of arsenic is at risk. Ethnic origin has no influence in the development of arsenicosis.
- (iii) Age is not a factor. The youngest reported patient was three years old in the drinking water-affected areas and six months old in the coal burning-affected areas. Some of the patients are 80 years old. The incidence of arsenicosis increases with age in the affected areas of both types because of the accumulation of arsenic in the body. It is the accumulation that is believed to cause severe harm to human health, including the development of cancer. It should be noted that in highly affected areas, many school age children between 6 and 15 years old have been diagnosed with arsenicosis.
- (iv) The reported incidence in males is slightly higher than in females for both types. That may be due to a larger amount of arsenic intake from contaminated water and food as males tend to consume more food and water. However, in some places significant differences between males and females were detected while in others there were no differences.
- (v) The disease tends to affect members of the same household. Frequently, two or more members are affected in one family, while in many families all members are affected.
- (vi) About 50 percent of the population at risk is female and 20 percent is children. In particular, a large number of pregnant women, lactating mothers and infants are continuously exposed to high arsenic in their water, food

and environment. Chronic arsenic poisoning is, therefore, a great threat to the healthy growth and cognitive development of children.

5. Factors effecting arsenicosis manifestation in China

Chronic arsenic poisoning is due to accumulation of arsenic in the body. However, even under similar arsenic exposure and environment, symptoms vary among members of the same family. Based on the information collected in China, chronic arsenic poisoning is attributed to the following factors (with some unknown factors acknowledged):

Arsenic intake and its chronic toxicity

Chronic toxicity of arsenic in human is proportional to the total arsenic intake either from drinking water or contaminated food and air. A study in Xinjiang shows that the higher the arsenic concentration in drinking water, the higher is the number of confirmed arsenicosis cases (4). According to recorded observations, symptoms such as skin hyper-pigmentation, hypo-pigmentation and hyperkeratosis vary from person to person.

Such symptom variation is more complicated in the coal burning-affected areas as the total arsenic intake is from arsenic in the dried corn, peppers as well as the air. The poisoning becomes more complicated because the arsenic intake from dried food passes through the digestion system, while from the air it goes through the respiratory system.

Latent period of arsenicosis manifestation

The latent period to develop chronic arsenic poisoning in humans depends on the amount of arsenic intake. According to the observations of several centres for endemic disease control, newcomers to high arsenic areas in Inner Mongolia became sick after two to three days of consuming well water that had an arsenic concentration of

860 ppb; new settlers in arsenic-affected areas in Xinjiang developed arsenicosis symptoms after two months of consuming well water containing arsenic of 750 ppb (4). In the drinking water-type endemic areas, generally, it takes about 8-10 years to develop skin lesions. But when exposed to increased levels of arsenic, victims can develop symptoms within five to six years. In the coal burning-type endemic areas, the latent period is shorter than the drinking water type and more severe symptoms manifest (4). However, clinical arsenicosis has been diagnosed in children as young as 6-18 months of age. This indicates the possibility of the transfer of arsenic toxicity from mother to child. Research studies are being carried out to identify the possible pathways.

Complications from other health-related chemicals in groundwater and in contaminated dried food

In both the drinking water- and coal burning-affected areas, the problem is not limited only to high levels of arsenic. High levels of fluoride also are found in groundwater and contaminated dried foods in almost all endemic arsenicosis areas. Furthermore, high and low iodine concentrations also have been detected in groundwater in some areas where high levels of arsenic and fluoride have been found. In fact, there are certain areas in China where high levels of arsenic, fluoride and iodine co-exist in the groundwater of aquifers at different depths. In some areas, it was reported that many inhabitants had suffered from both arsenicosis and fluorosis, thus complicating the practicality of providing safe drinking water by developing local groundwater sources. This complexity has existed in many areas for years. There is a need to investigate the co-influence on human health of these chemicals in drinking water and in contaminated food. In certain affected areas in Inner Mongolia, some wells were observed having natural gas bubbling through the water. Initial test of these well water samples indicate the existence of a large amount of fluorescent substance together with a high arsenic concentration (8). However, no

"black foot disease" similar to that found in Taiwan province has been identified among arsenicosis patients in these affected areas.

Other possible influencing factors

Almost all endemic chronic arsenic poisoning areas in China are in the economic weak rural areas. Malnutrition among both adults and children is very common. Insufficient protein intake and an unbalanced diet may weaken the body's resistance to chronic arsenic poisoning. More studies are needed to assess the effect of nutritional factors on the manifestation of arsenicosis in humans, particularly in children.

6. Clinical and sub-clinical symptoms of arsenicosis patients in China

Non-specific sub-clinical symptoms, such as anorexia, sleep disorder, tiredness and general malaise, are frequent manifestations during the latent period. During the clinical period, skin pigment change and hyperkeratosis develop. Symptoms have been observed as (4):

- (i) Arsenic-specific skin hyper-pigmentation and hypo-pigmentation. Skin pigment changes vary depending on individuals. One kind is the body skin darkening to a grey and slight black colour. The other is that hyper-pigmentation exists in combination with hypo-pigmentation, which usually takes place in unexposed parts of the body in a symmetric manner. The combination of hyper-pigmentation and hypo-pigmentation takes the shapes of pin heads, corn grains or raindrops, locally known as "raindrop tummy". In severe cases, even oral mucosa and the genitals could be affected.
- (ii) Arsenic-specific hyperkeratosis of the palms and soles. Hyperkeratosis

often affects the palms and soles symmetrically. At the early stage, subcoetaneous mini-papules emerge, which can be felt when touched. They form small papules and verrucae and subsequently coalesce into pieces. Eventually it decreases the patient's ability to work.

- (iii) Chronic arsenic-related peripheral neuritis is the most common form of injury of the nervous system, with optic and auditory nerves being affected occasionally. Symptoms often occur at the early stage.
- (iv) Damage to the circulation system usually appears as peripheral circulation disturbance. Many patients complain of coldness of extremities. In severe cases, patients usually complain of chest distress, post nostalgia and shortness of breath.
- (v) Non-specific symptoms of the impact on the digestive system, such as abdominalgia, diarrhoea and dyspepsia, are commonly observed among patients suffering from either type. Hepatomegaly and hepatocirrhosis are found more often among patients of poisoning in coal-burning areas.
- (vi) A mental slowing or loss of memory is observed in some patients. The patients can suffer from slow thinking, blackouts or amnesia.
- (vii) Bowen's disease and skin cancer. The hyperkeratosis areas on the palms and soles may result in erosion, ulceration and pain. Keratosis, or spotted melanosis, on the body may deteriorate and result in surface roughness, erosion, ulceration, pain and surrounding skin flush. Pathological diagnosis for Bowen's disease and skin cancer only can be made by biopsy.

Importance of laboratory biopsy

Arsenic concentrations in the hair and urine of affected people are important indicators of chronic arsenic poisoning. The arsenic value in urine reflects recent arsenic intake. However, when testing for arsenic in the urine, care should be taken to note whether the person had eaten any seafood such as fish or prawns because they contain high levels of organic arsenic that is excreted in urine. As a reference, the average arsenic urine value in China in non-arsenic affected areas is below 0.09 mg/l (4). The arsenic level in hair indicates the accumulated arsenic in the body within a certain period. According to the Ministry of Health, the average Chinese hair arsenic level in non-arsenic affected areas is 0.6 ug/g (9). Studies in China have revealed that the development of arsenicosis is proportional to the concentration of arsenic in hair (4).

7. Long-term chronic arsenic toxicity and endemic cancer in China

A positive correlation between the mortality of malignant tumours and the arsenic level in drinking water has been observed in the endemic areas in China. In a long-term study in Heihe village, one of the endemic arsenicosis villages in Inner Mongolia where inhabitants have consumed arsenic-contaminated water for more than 30 years, malignant tumours top the list of mortality causes at 71.72 percent. Cancer mortality of the respiratory system, digestive system and the skin accounted for 38.5 percent, 35.9 percent and 14.1 percent, respectively (4). Arsenic is a definite carcinogen to humans. The latent period for chronic arsenic-related cancer could be 20-30 years. As the inhabitants in most endemic areas in China now have been exposed to high levels of arsenic for some 20 years, there is a considerable likelihood of a cancer outbreak in the coming years.

Observations in China have shown that cancer in all organs, particularly lung cancer, continued to develop in arsenicosis patients

even after they had stopped consuming water containing high levels of arsenic. In a follow-up of cancer incidence study in an arsenic-affected area in Xinjiang from 1980 to 1995, six cases of cancer-related deaths (involving five different body organs) were reported in the eight years before the provision of an alternative arsenic-safe water supply. But there were thirteen cases of cancer-related deaths in the same area eight years *after* the provision of a permanent arsenic-safe water supply. Nine of the thirteen cases were lung cancer (4), which was obviously a higher incidence than in the non-arsenic-affected drinking water area. This indicates the continuous cancerization of human organs even after consumption of arsenic ends. Therefore, endemic cancer among the affected populations due to long-term chronic arsenic toxicity could be a serious public health problem in the arsenic-affected areas. This is critical for advocacy to create awareness among policymakers in the arsenic-affected countries. These policymakers not only have to take urgent action for early detection of arsenic in wells in affected and at-risk areas, but they also need to allocate adequate financial inputs and to provide permanent arsenic-safe water supplies to eliminate or reduce the healthcare burdens and ultimately the suffering among people.

As the magnitude of endemic chronic arsenic poisoning areas in China remains unclear, more effective measures are needed to screen all highly contaminated wells. Providing alternative arsenic-safe water supplies or improved stoves are the correct ways to cut arsenic intake and thus reduce the number of arsenicosis patients and the potential cancer peak in rural China in the future. Until those provisions occur, people need to be motivated to use wells in their neighbourhood that have an arsenic concentration that is less than the government standard of 50 ppb, and if possible, to use alternative food-drying methods. This is a very valuable lesson for other arsenic-affected countries to learn and to take action in preventing a public health calamity involving endemic arsenic-induced cancer.

8. China's approach for prevention of endemic chronic arsenic poisoning

The Government's approach to prevent endemic chronic arsenic poisoning in China by eliminating sources of arsenic intake is twofold: early detection of arsenic contamination in drinking water, foods and environment as well as identification of arsenicosis patients; and the provision of the permanent alternative arsenic-safe water supplies to the affected population and improved stoves to the affected households. The concerned government agencies are planning to carry out research studies in searching for effective treatment of hyperkeratosis and the prevention of cancer induced by long term exposure to high arsenic.

Early detection and prevention

For effective dealing with the emerging chronic arsenic poisoning problem in China, the Government is coordinating with various agencies to test arsenic concentration in wells in affected areas and to identifying arsenicosis patients. The Ministry of Health, with the support of local provincial governments, is responsible for testing the arsenic concentration in wells in the affected areas. UNICEF has provided some financial assistance in carrying out wide-scale testing of arsenic concentration in wells in high-risk areas in the six affected provinces/autonomous regions of Xinjiang, Shanxi, Inner Mongolia, Jilin, Ningxia and Qinghai. A practical method of sampling 10 percent of wells in affected areas (using village as a unit) where water samples are taken from wells in five locations (east, south, west, north and centre) has been developed based on the accumulated field experience. This method is to determine whether wide-scale testing of arsenic content in all wells of a particular village is necessary. When one well in the 10 percent surveyed has an arsenic level higher than the government standard of 50 ppb, all wells in the village are then tested. Wells having arsenic levels higher than 50 ppb are marked and mapped indicating the ranges of

arsenic concentration. This type of mapping becomes a valuable tool to advocate the Government for allocation of funds for the provision of arsenic-safe water supplies to the affected rural population with priority given to the areas having the highest arsenic level in wells. It also serves as an effective motivational tool to advise people to use their neighbours' wells that are arsenic-safe as an interim measure while waiting for the provision of an arsenic-safe water supply. National and provincial maps of well locations and arsenic concentration are being developed based on the available data.

Subsequent to the detection of endemic chronic arsenic poisoning in extensive areas in China, Chinese specialists in arsenic research, clinicians, epidemiologists and toxicologists developed in 1998 some guidelines for the diagnosis of arsenicosis. These guidelines have proven to be an important tool and reference in the early diagnosis of arsenicosis. The Ministry of Health approved the guidelines in 2003. (10)

Provision of arsenic-safe water and improved stoves

The Ministry of Water Resources is working with local governments to provide arsenic-safe piped water supplies to the most-affected areas on priority basis, in accordance with the recommendations of the Ministry of Health. Some of the arsenic-safe piped water schemes are shown in Figure 9, 10 and 11. While the Government has yet to develop



Figure 9: Pumping station of an arsenic-safe piped water supply system, Inner Mongolia autonomous region, China



Figure 10: A water tower of an arsenic-safe piped water supply, Shanxi province, China



Figure 11: Villagers collecting arsenic-safe piped water from a water point by using a pre-paid magnetic card, Shanxi province, China

a policy for endemic chronic arsenic poisoning prevention, substantial budgeting will be required by the central and local governments for testing arsenic contamination in all wells in the vast known affected areas and the potentially affected areas. The Government has allocated a sizeable budget (RMB850 million, which is equivalent to US\$106 million), in late 2000, to the Ministry of Water Resources for the provision of alternative arsenic-safe and fluoride-safe water supplies in high-risk areas. (11) But the funds cannot meet the demand. Other options of alternative arsenic-safe water supplies are to be promoted, such as the household harvesting rain and snow and the installation of household sand filters to remove arsenic in well water through co-precipitation with optimum iron content in the well water

In coal-burning arsenic affected areas, the promotion of improved stoves and adoption of an alternative drying process for corn and peppers, coupled with behaviour change, are the necessary measures to

eliminate the sources of arsenic intake. Some of the improved stoves installed in households in Guizhou province are shown in Figure 12, 13 and 14.



Figure 12: An improved stove with chimney has replaced the conventional open stove in a rural household, Guizhou province, China



Figure 13: The chimney of the improved stove vents away the arsenic-contaminated smoke in the house, Guizhou province, China

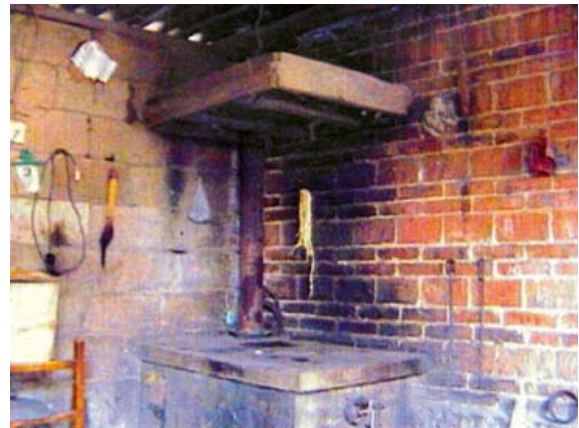


Figure 14: An improved stove in a rural household; the chimney vents the arsenic-contaminated smoke out of the kitchen, Guizhou province, China



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Standard of diagnosis for endemic arsenitosis
(征求意见稿)

发布

实施

中华人民共和国卫生部 发布

*Chinese Guidelines for
Clinical Diagnosis of Arsenicosis*

Key Points of the Chinese Guidelines for Clinical Diagnostic of Arsenicosis

1. Definition

Endemic arsenicosis is a disease caused by long-term exposure to high levels of arsenic in groundwater (due to geological formations) or by breathing air and eating dried foods contaminated by the burning of coal containing high levels of arsenic. It is characteristic of dermatological metamorphoses and is strictly limited to specific arsenic-affected areas.

2. Diagnostic criteria

Essential conditions

For inhabitants of endemic areas who have been drinking water containing higher than the safe limits of arsenic or eating the arsenic contaminated corn and hot peppers dried by burning highly contaminated coal for cooking in open stoves inside the house (to keep warm and to dry corn and hot peppers) and thus have had long-term over-exposure to arsenic, the emergence of skin lesions is indicative of arsenicosis.

3. Skin lesions as the major diagnosis index

Clinical investigations indicate that chronic arsenic poisoning induces it harmful effects to various organs in the human body, including injury of the nervous system and peripheral circulation disturbance. The resulting skin lesions are most prominent and therefore observationally distinguishable. Also, skin lesions induced by arsenicosis tend to emerge at a relative early stage and are of such specificity that they make for easy examination and diagnosis. Thus, the guidelines for diagnosis of arsenicosis are based upon symptoms of skin lesion manifestations. (10)

Fundamental diagnostic symptoms index

Hyperkeratosis on the palms and soles, the cause of which is difficult to elucidate

Hyper-pigmentation and/or hypopigmentation that emerges on the skin of the unexposed body areas and the cause of which is difficult to elucidate.

Referential diagnostic symptoms index

Peripheral neuritis (sensory and motor polyneuritis and myophagism), the cause of which is difficult to elucidate

The arsenic levels in urine or hair samples are significantly higher than the normal levels in non-epidemic areas of the same region.

4. Dermatological metamorphosis classification

Hyperkeratosis on the palms and soles

Grade I: Scattered corn-like nodular hyperkeratosis on the palms and soles that are visible to the naked eye and/or can be detected by pressing with the thumb.

Grade II: More and larger distinct papulous-like hyperkeratosis on the palms and soles.

Grade III: Widespread maculae or streaky hyperkeratosis on the palms and soles, or several large verrucose hyperkeratosis either on the palms and soles or on the dorsum of the hands and the soles, with fissuring, ulceration and bleeding in some cases.

Coetaneous hyper-pigmentation

- Grade I: Slightly darker pigment changes of the skin of unexposed body areas, mainly on the trunk, or the appearance of areas of lighter pigment among the symmetrical dark brown patches.
- Grade II: Skin pigment on unexposed body areas, mainly on the trunk, that has turned grey or the appearance of large verrucous dark brown plaques in varied tones.
- Grade III: Skin pigment on unexposed body areas, mainly on the trunk, that have turned grey or are accentuated in areas that are more heavily pigmented with clusters of mottled dark brown patches measuring about 1 cm in diameter.

Coetaneous hypo-pigmentation

- Grade I: Hypo-pigmentation that appears on unexposed areas of the body, mainly on the trunk, as symmetrically scattered pale spots the size of pin heads.
- Grade II: Hypo-pigmentation that is accentuated on unexposed areas of the body, mainly on the trunk, as hypo-pigmented spots.
- Grade III: Hypo-pigmentation that occurs on unexposed areas of the body, mainly on the trunk, in an extensive and confluent manner.

Bowen's disease and skin cancer

The hyperkeratosis areas on the palms and soles may result in erosion, ulceration and pain. Keratosis, or spotted melanosis, on the body may deteriorate and result in surface roughness, erosion, ulceration, pain and surrounding skin flush. Pathological diagnosis for Bowen's disease and skin cancer only can be made by biopsy.

5. Classification of clinical diagnosis

Suspicious cases

The presence of hyper-pigmentation Grade I or hypo-pigmentation Grade I or the appearance of only one or two corn-like nodules on the skin of the palms and soles
Inhabitants in epidemic areas using contaminated coal who exhibit visual deterioration, hypogeusia and loss of appetite.

Mild cases

Presence of hyperkeratosis Grade I on the palms and soles or simultaneous appearance on the skin of the trunk of hyper-pigmentation Grade I and hypo-pigmentation Grade I
Peripheral neuritis or levels of arsenic in urine and hair samples that are significantly higher than the normal level found in non-epidemic areas of the same region.

Moderate cases

Hyperkeratosis on the palms and soles and hyper-pigmentation and hypo-pigmentation of the skin on the trunk – with one of the said symptoms falling into Grade II.

Advanced cases

Cases showing hyperkeratosis on the palms and soles and hyper-pigmentation and hypo-pigmentation of the skin on the trunk – with one of the said symptoms falling into Grade III.

Bowen's disease and skin cancer

Definite pathological diagnosis has to be made by biopsy.



Training of Medical offices and health workers on diagnosis of arsenicosis, China

Photo Illustrations of Skin Lesions of Arsenicosis Manifestations

This section presents a collection of photos to illustrate the stage-by-stage manifestations from mild to advanced cases of arsenicosis, based on the dermatological metamorphosis classification of the Chinese guidelines on

clinical diagnosis. The depiction of the various stages of symptoms should prove helpful to medical professionals and health workers in identifying arsenicosis.

1. Hyperkeratosis on the palms (symptoms manifested from mild to advanced cases in adults)

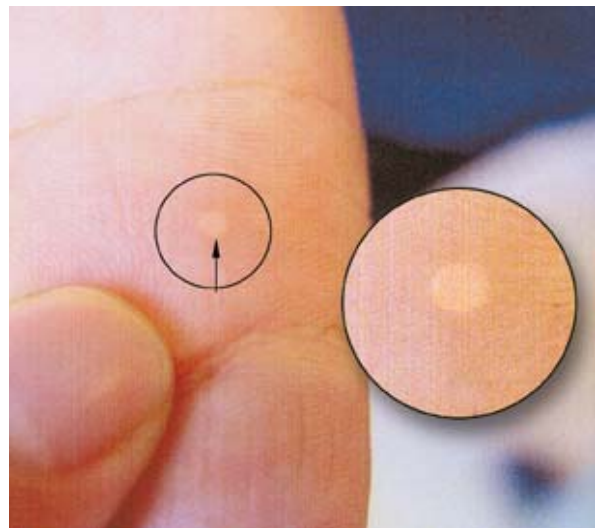


Photo 1: Early stage of hyperkeratosis; the nodi are unobtrusive but appear when the skin is stretched



Photo 2: Early stage of hyperkeratosis; an obvious nodule of corn size is visible on the palm

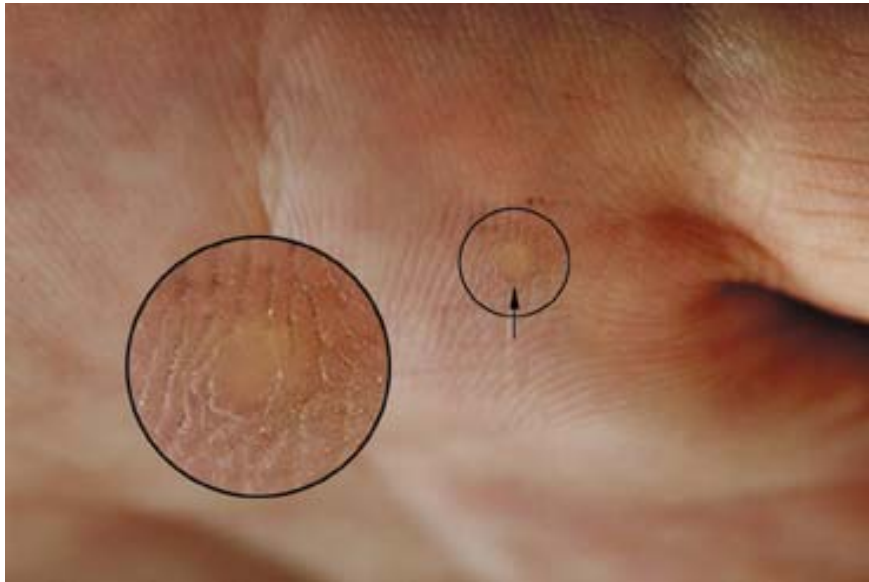


Photo 3:
Early stage of hyperkeratosis; the nodi can be seen on the palm and can be felt distinctly by touching



Photo 4 :
Early stage of hyperkeratosis; some scattered corn-like nodi appear distinctly on the palm



Photo 5:
Mild case of hyperkeratosis; some scattered corm-like nodi can be seen between the two thenar eminences



Photo 6:
Mild case of hyperkeratosis; corn-like nodi in different sizes appear in the thenar area



Photo 7:
Diffuse and tiny corn-like nodi on the palm, especially noticeable on the hypothenar



Photo 8:
Moderate case of hyperkeratosis; more and larger distinct nodi on some parts of the palms



Photo 9:
Relatively large coalescing
bean-sized nodi on the
palm



Photo 10:
Coalescing plaques on
the hypothenar; scattered
bean-sized nodi visible



Photo 11:
Plaques of scattered
hyperkeratosis on the
palm that are spreading to
the wrist

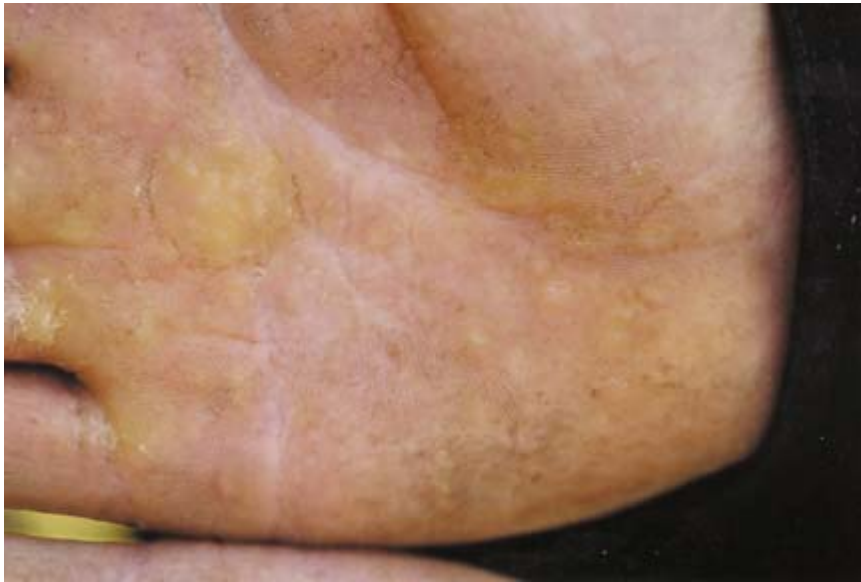


Photo 12:

Plaques of hyperkeratosis on the palm, with a strip of hyperkeratosis on the hyperthenar and scattered bean-sized nodi on other parts



Photo 13:

Hyperkeratosis on the palm that is spreading to the fingers

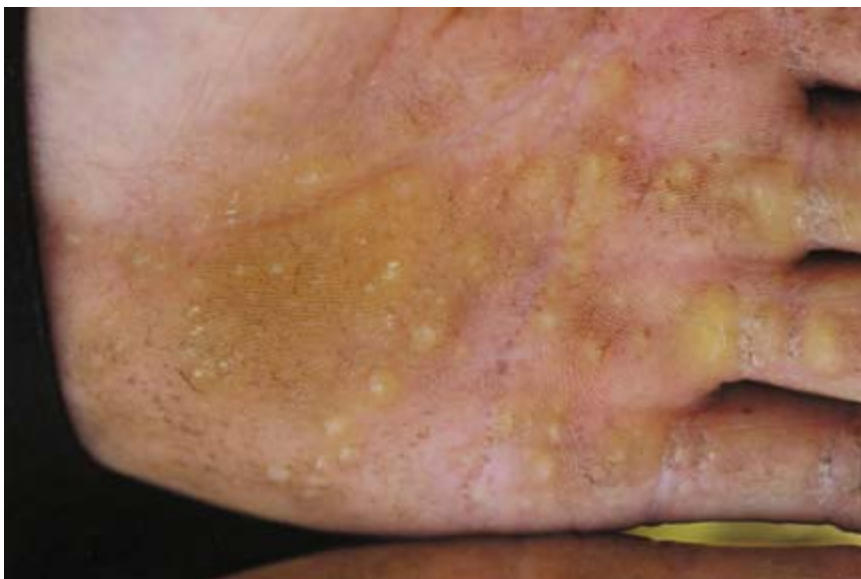


Photo 14:

Advanced case of hyperkeratosis; large plaques and streaky hyperkeratosis have formed on the palm and are spreading to the fingers



Photo 15:
Coalescing plaques on the palm, especially on the thenar; fingers are seriously affected



Photo 16:
Hyperkeratosis coalescence of large and streaky plaques on the palm



Photo 17:
Hyperkeratosis on the palms and fingers and spreading towards the wrist; hyperkeratosis plaques have formed on the thenar of the right hand (This patient lost one and a half fingers in an accident and not due to arsenicosis)



Photo 18:

Severe plaques and streaky hyperkeratosis on the palms and fingers, with coalescing plaques covering almost the whole right palm



Photo 19:

Advanced case of hyperkeratosis; coalescing plaques cover the palm; this patient has great difficulty in flexing his fingers



Photo 20:

Advanced case of hyperkeratosis on both palms; the coalescing plaques on the left palm have been cut to reduce the thickness for ease of movement



Photo 21:

Wart- or tumor-like prominence on the palm that has spread to the back of the palm; fingers are also seriously affected



Photo 22:

Wart- or tumor-like nodi are spreading to the back of the palms; coalescence has formed on the back of the right thumb



Photo 23:

Wide-spread but uneven, dry and rotting root-like plaques of hyperkeratosis on the palms; fingers and the back of both thumbs are severely affected

2. Hyperkeratosis on the soles (symptoms manifested from mild to advanced cases in adults)



Photo 24:
Early stage
hyperkeratosis; scattered
corn-like nodi on the sole



Photo 25:
Early stage of
hyperkeratosis; visible
corn-like nodi on the sole



Photo 26:
Early stage of
hyperkeratosis; scattered
corn-like nodi on the sole



Photo 27:
Early stage of
hyperkeratosis; different
sizes of corn-like nodi
scattered on the sole



Photo 28:
Early stage of
hyperkeratosis; tiny nodi
on the arch can be felt
unmistakably by touching



Photo 29:
Scattered nodi on the arch
beginning partial coalescence



Photo 30:
Spreading corn-like nodi
on the medial arch



Photo 31:
Moderate case of
hyperkeratosis; more or
larger distinct nodi on the
sole with partial coalescence occurring



Photo 32:

Coalescence in large area occurs and appears transparent; toes are affected



Photo 33:

Scattered wart- or tumor-like nodi on the sole; toes also are affected; the patient suffers disorder in the blood circulation of toes



Photo 34:

Wart-like nodi on the heel; patient experiences pain while walking



Photo 35:

More and larger distinct papule-like nodi on the sole; extensive coalescences occur on the sole and toes; patient experiences pain while walking



Photo 36:

Hypokeratosis on the sole has spread to the instep and coalescence takes place gradually

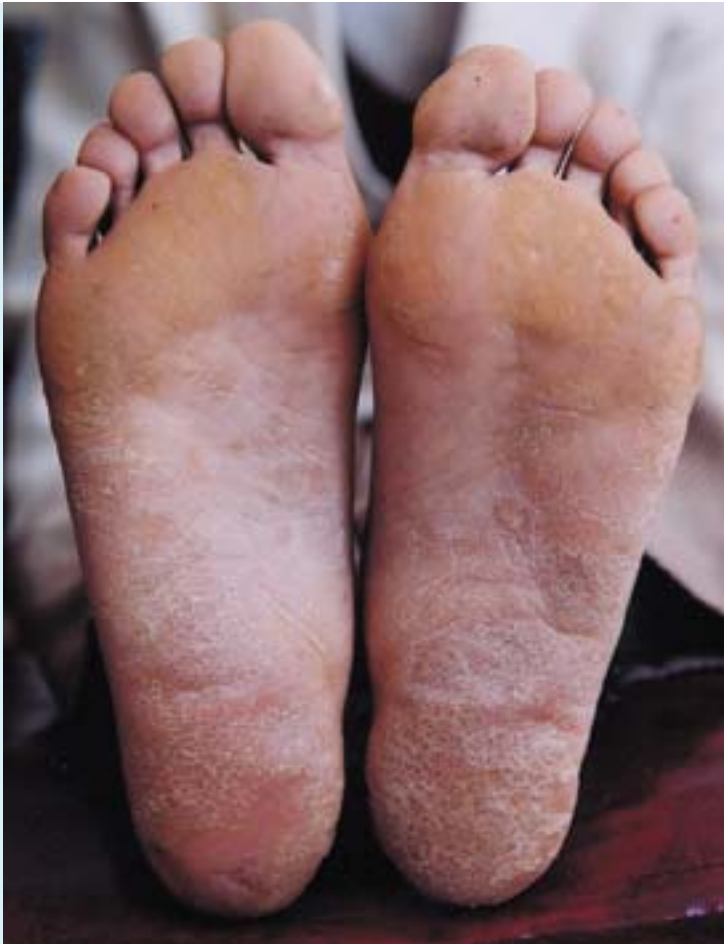


Photo 37:

Flaky and hard nodi form on the foresides and heels of both soles; scattered nodi appear on the arch



Photo 38:

Advanced case of hyperkeratosis; coalescence of plaques in different shapes has formed on the soles and toes; vestige of cutting on both heels is visible (the coalescent plaques on the soles are cut to reduce the thickness for easing pain while walking)



Photo 39:
Advanced case of hyperkeratosis; coalescence of hyperkeratosis on the soles and toes resemble a "shoe-pad"



Photo 40:
Transparent coalescing nodi with rhagas; vestige of cutting on the heel is visible



Photo 41:
Advanced case of hyperkeratosis on the sole and toes resembles fish scales

2.1 Hyperkeratosis on the soles (symptoms manifested in children and adolescences)



Photo 42:
Arsenicosis in children;
hyperkeratosis on the
soles of a boy aged 10



Photo 43:
Arsenicosis in children;
hyperkeratosis on the
soles of a boy aged 13



Photo 44:
Arsenicosis in children;
scattered corn-like nodi
on the soles and toes of
a boy aged 14

3. Coetaneous hyper-pigmentation and hypo-pigmentation on the trunk (symptoms manifested from mild to advanced cases in adults)



Photo 45:

Hyper-pigmentation caused by chronic arsenic poisoning; the colour of the skin on the non-exposed part becomes darker

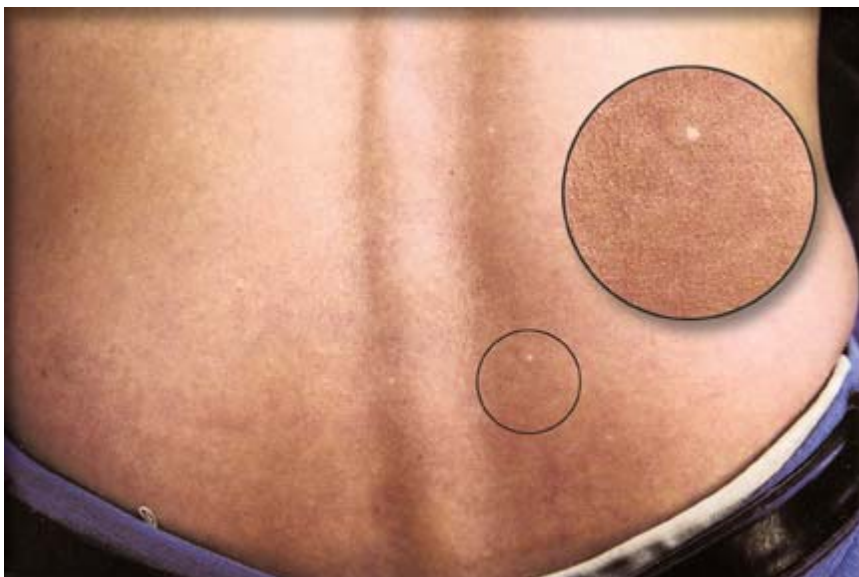


Photo 46:

Murky skin colour appears on the back with several scattered pinhead-size pale dots characterized by hypo-pigmentation

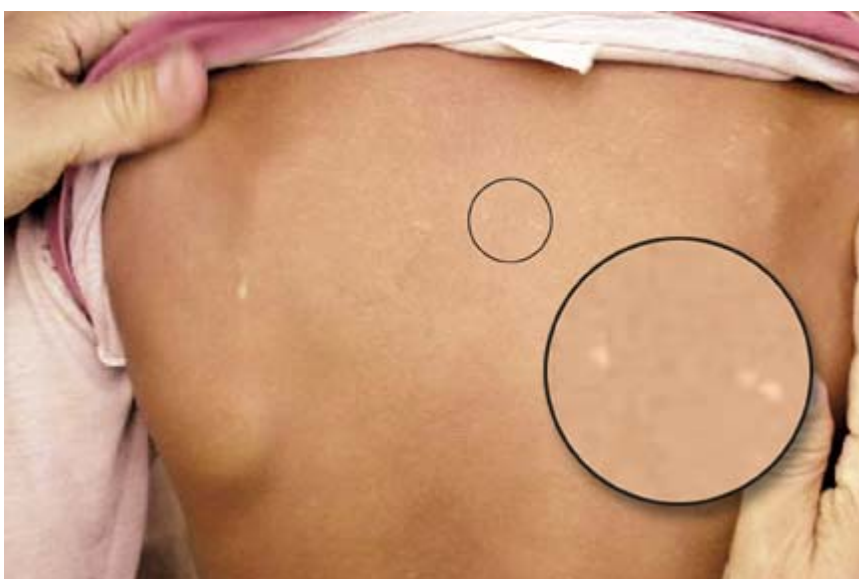


Photo 47:

The back of a patient; the skin colour darkens with scattered pale dots of hypo-pigmentation



Photo 48:

The skin colour of the back darkens; scattered pale dots of hypo-pigmentation appear in the lower back, especially along the waist

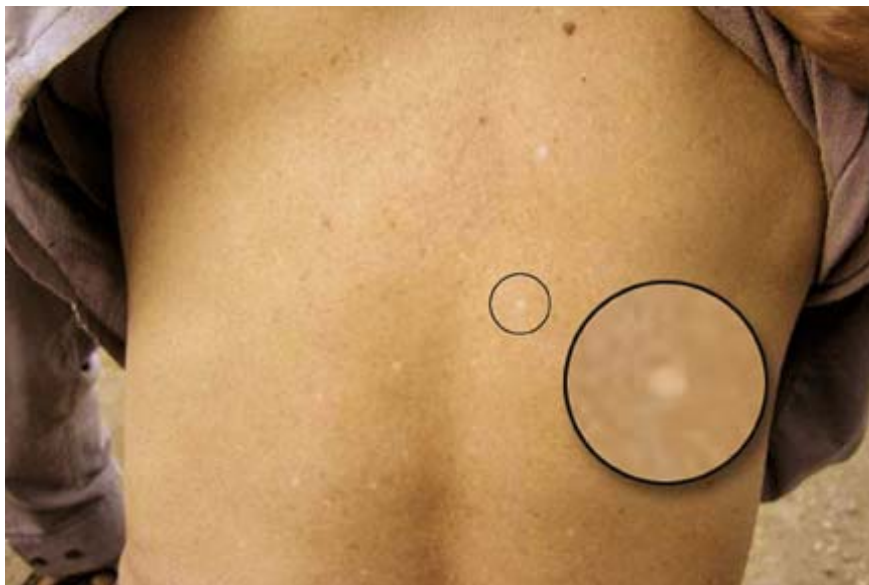


Photo 49:

The skin becomes a murky grey colour with many brown spots characterized by hyper-pigmentation and scattered pale dots of hypo-pigmentation



Photo 50:

The skin of the back becomes a darker colour with scattered brown spots of hyper-pigmentation and few pale dots of hypo-pigmentation



Photo 51:

The skin appears gray colour on the back with scattered brown dots of hyper-pigmentation and pale dots of hypo-pigmentation



Photo 52:

Hyper-pigmentation and hypo-pigmentation co-existent on the chest



Photo 53:

The colour of the belly skin becomes darker with varying sized but scattered symmetrical pale dots of hypo-pigmentation



Photo 54:

Hyper-pigmentation is more severe than hypo-pigmentation on the belly skin with distinct brown spots of hyper-pigmentation



Photo 55:

Changes in the skin pigmentation from advanced case of chronic arsenic poisoning; the colour of the chest and belly skin become obviously darker with many brown spots of hyper-pigmentation and pale dots of hypo-pigmentation

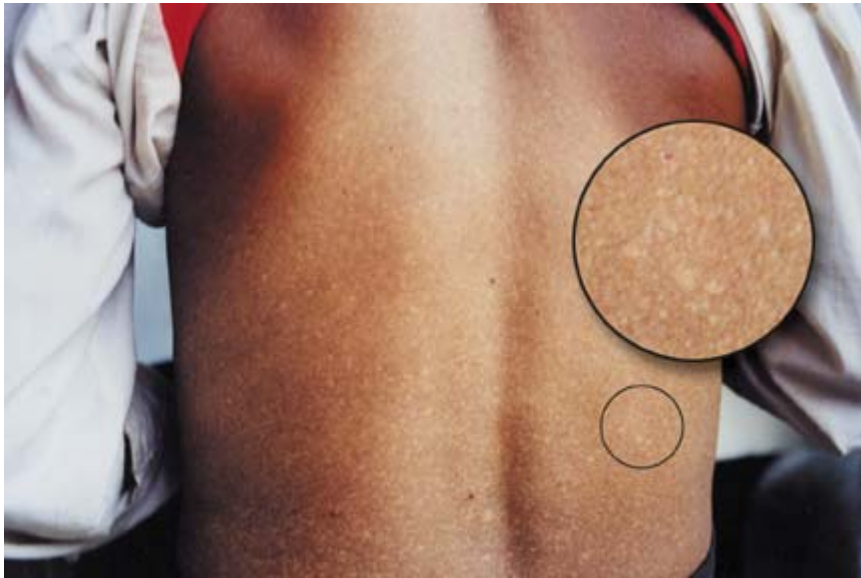


Photo 56:

The back becomes darker colour with brown spots of hyper-pigmentation and widespread pale dots of different-sized hypo-pigmentation



Photo 57:

The chest skin appears a dark colour with scattered dark brown dots of hyper-pigmentation and large white pale spots of hypo-pigmentation



Photo 58:

The skin becomes darker with many dark brown dots of hyper-pigmentation and large pale spots of hypo-pigmentation



Photo 59:

Colour of the belly skin becomes a dark gray with different-sized dark brown dots of hyperpigmentation and various sizes pale spots of hypopigmentation



Photo 60:

Skin metamorphosis in an advanced case of chronic arsenic poisoning; the skin becomes a murky grey colour, with a coalescence of hypopigmentation spots

3.1 Coetaneous hyper-pigmentation and hypo-pigmentation on the trunk (symptoms manifested in children and adolescences)



Photo 61:

A boy aged 3 with hyper-pigmentation; the colour of the skin becomes obviously darker but without hypo-pigmentation

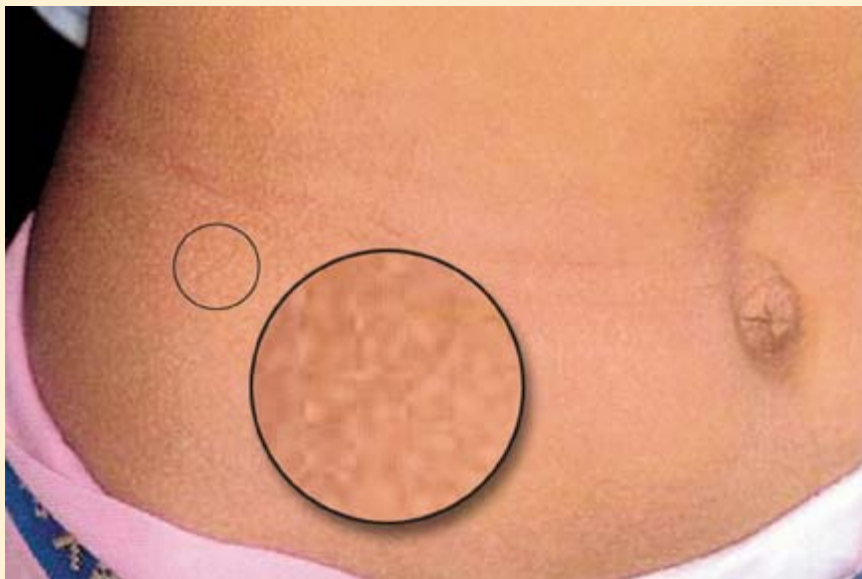


Photo 62:

The belly skin of a child becomes rough and the colour appears darken



Photo 63:

A child aged 14 with distinct pale spots of hypopigmentation on his chest

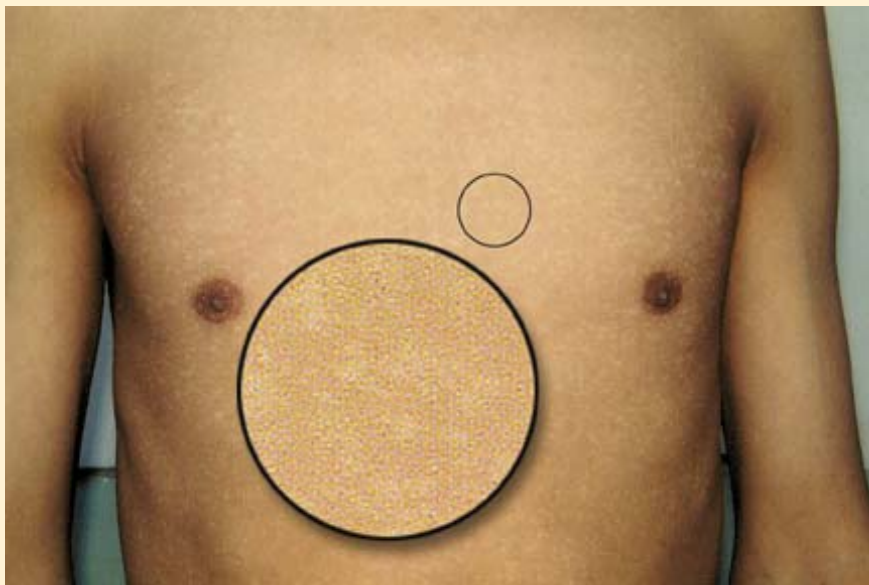


Photo 64:

An enlarged picture of the boy's chest (photo 63) shows clearly the pale spots of hypopigmentation



Photo 65:

Widespread hyper-pigmentation and hypo-pigmentation on the skin of the chest and belly of a young man aged 18; the skin becomes darker



Photo 66:

An enlarged picture of the patient (photo 65) shows a cluster of pale spots of hypo-pigmentation on the skin



Photo 67:

Further enlarged picture of the belly skin of the patient (photo 66) showing a coalescence of pale spots of hypo-pigmentation

4. Bowen's disease and skin cancer

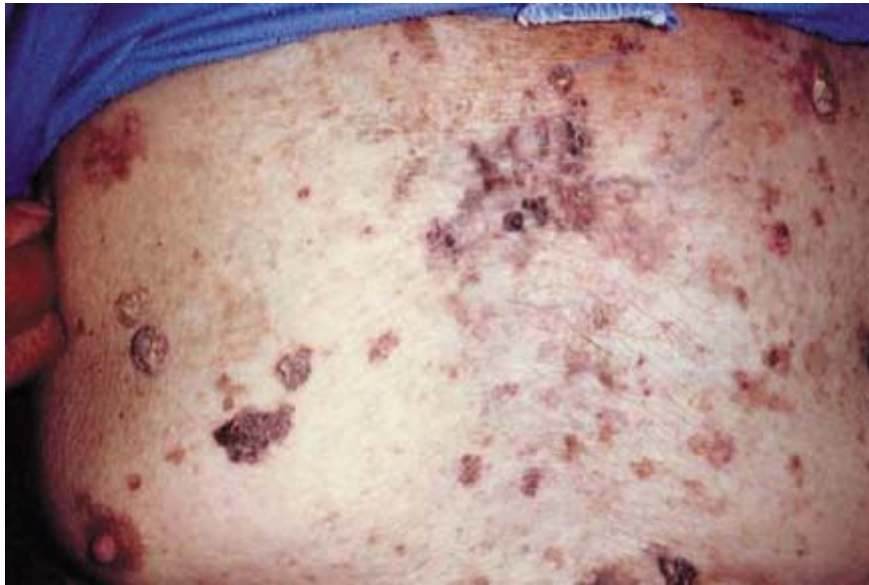


Photo 68:

Bowen's disease; rough and protruded nodi of different sizes and darkened spots of pigmentation appear on the chest, back and other parts of the body; erosion, ulcer and flush occur in some cases



Photo 69:

A male patient with Bowen's disease caused by chronic arsenic poisoning



Photo 70:

A female patient with Bowen's disease caused by chronic arsenic poisoning



Photo 71:

A male patient with Bowen's disease caused by the coal-burning type of chronic arsenic poisoning in Guizhou province; many nodi of different sizes are scattered on the trunk; flush is distinct in the two nodi indicated



Photo 72:

Bowen's disease caused by the coal-burning type of chronic arsenic poisoning; erosion and ulcer appear in the nodi on the forearm; carcinomatous change occurs

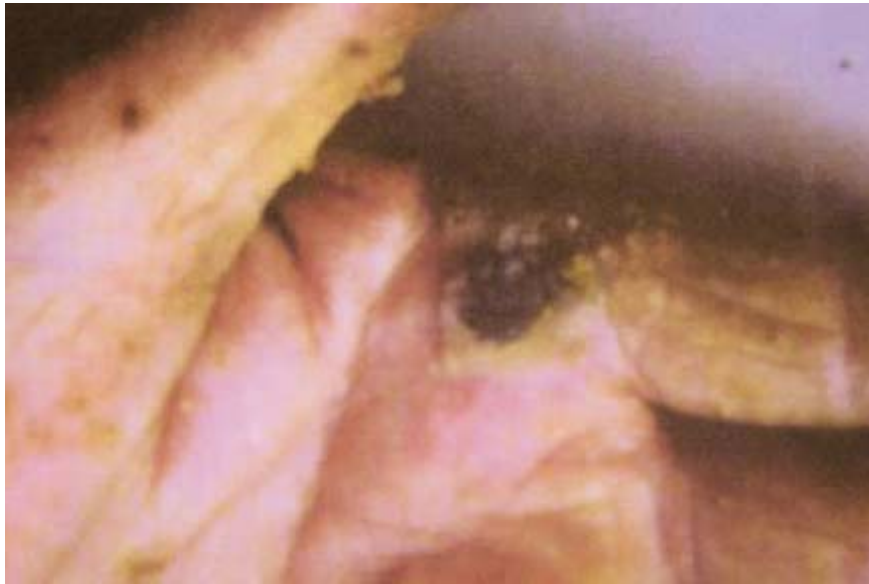


Photo 73

Skin cancer caused by arsenicosis; the cancer attacks the inferior part of the forefinger; nodi of hyperkeratosis are clearly observable on the palm



Photo 74

Hyperkeratosis on the palms of a coal-burning type arsenicosis patient; the thumb with malignant tumor on the right hand has been removed



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