

Classification of tattoo complications

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ABSTRACT

There is information about side effects of tattoo caused both by skin injury and the effect of the dyes used. However, these data are scarce and contradictory, there is no classification of complications, which determines the relevance of this study.

Objective — the study was aimed at systematizing tattoo complications, developing classification and preventive measures based on analysis of literature and our own clinical data.

Material and methods. We analyzed publications in the PubMed (1997—2017) dealing with tattoo complications. We accumulated the database of clinical cases of complications after tattoo procedure. Clinical and laboratory diagnostics included history taking, examination, dermatoscopy, allergy tests, bacteriological examination, immunofluorescence tests, enzyme-linked immunosorbent assay, and histological examination of biopsy samples of tattooed tissue.

Results. Compounds with pronounced toxic, mutagenic and carcinogenic effects were found in the pigments used for tattoos. Allergic reactions in the form of anaphylactic reaction (0.1%), urticaria (3%), contact dermatitis (19.9%), and eczema (7%) are the most common complication. There were cases of HIV (3%) and hepatitis (8%) infection. Secondary infection was observed in 15% of cases. Side effects were characterized by pronounced polymorphism (purulent-inflammatory, degenerative, necrotic, and neoplastic processes). We proposed a classification of tattoo complications based on the studies systematizing the available information about the side effects of tattoos.

Conclusion. Given the invasiveness of the procedure and significant number of complications, the list of contraindications for the use of tattoo should be developed; mandatory certification of injected dyes should be used; standards for preliminary laboratory studies prior to this invasive procedure should be developed; higher requirements for specialists performing tattooing should be used; the workplace of a tattoo master should be certified with allowance for the compliance with aseptic and antiseptic techniques.

Keywords: tattoo, tattoo pigments, tattoo complications, classification of tattoo complications.

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Tattooing is an artificial lesion of skin with the use of piercing/cutting instruments for the purpose of inserting coloring materials into the dermis layer of the skin with the aim to produce permanent, non-disappearing pictures or images. In recent years, cosmetic tattoos made by different techniques have become increasingly popular. The Polynesian style is considered to be the oldest, this ethnic style of tattoo originated from the Polynesian islands and is considered to be one of the most ancient samples of fine arts, indicating the religious and hierarchical positions. The traditional or old school style dates back as far as the early XX century in the USA and it is characterized by minimalism of images. Besides, there are techniques of tattoos in the realistic, dotwork, geometric, tribal, and Japanese styles. Tattoos in the blackwork style are covering of skin areas with a large-scale monochrome picture and, as a rule, points to a low social status of a person [1]. There is distinguished separately a permanent make-up,

which is very popular among women of various ages and social positions [2, 3].

But this cultural phenomenon has a flip side in the form of complications caused by tattoo procedures, the masters of tattoo parlors do not inform the clients about. All the tattoo dyes and pigments in the Russian Federation and abroad are not a subject to the obligatory certification, consequently, the safety of their use is not guaranteed, and the risk of side effect developments increases [4]. Monochrome black tattoos are based on carbon black containing polycyclic aromatic hydrocarbons and phenol, which are recognized mutagens and carcinogens [5]. Besides, there are data, that polycyclic aromatic hydrocar-

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bons under ultraviolet light are able to generate cytotoxic singlet oxygen, which could damage the skin continuity [6].

The majority of the pigments used for colored tattoos are produced for clothes dyeing, so often they are not intended for other use; some pigments are decomposed under sun light releasing aromatic amines as metabolites, which are carcinogens [7].

In the literature, there are data on side effects of tattoos caused both by skin injury and effects of the dyes used. However, these data are scarce and contradictory, there is no classification of complications, which determines the relevance of this study [8, 9].

Objective: To systematize tattoo complications, to develop a classification, and to outline preventive measures on the basis of the analysis of the literature and our own clinical data.

Materials and methods

The studies were carried out in several directions. At the first stage, we analyzed the publications in the PubMed (1997-2017) dealing with tattoo-caused complications. The analysis categories were united by the keywords characterizing the appearance of complications related to tattooing. The following keywords were taken: tattooing, tattoo, harmful effects, tattoo complications, skin reaction to tattoo, as well as various diagnoses containing the tattoo word.

Simultaneously, we accumulated a database of clinical cases of tattoo complications selected on the basis of patient encounters to the Department of Laser Therapy and Other Instrumental Methods of Treatment and Diagnostics of the Moscow Scientific and Practical Center of Dermatovenereology and Cosmetology.

Clinical and laboratory diagnostics included history taking, examination, dermatoscopy, allergy tests, bacteriological examination, immunofluorescence tests, enzyme-linked immunosorbent assay, in some cases, a pathomorphological study of biopsy samples of tattooed tissue was carried out. For this purpose, a sample was put in 10% formalin for 24 h with pouring in paraffin blocks followed by a standard histologic examination, while staining sections with hematoxylin and eosin, and Van Gieson's stain. Photomicrographs were taken using a Leica DM 100 microscope equipped with a digital photo camera.

The statistical processing was carried out by the methods generally accepted for biomedical studies with the use of the EXCEL 7.0 (Microsoft, USA) and ARCADIA (Dialog-MGU, Russia) software packages.

Results

During the analyses, we have found that all tattoo parlors use non-certified pigments, which contain a series of admixtures and contaminants. A wide color palette is

used for tattooing, however, the chemical composition of pigments, as a rule, is not specified. It is determined that color and black pigments have different compositions. Moreover, carbon black still prevails in the composition of black dyes, while ingredients of color dyes contain a significant quantity of admixtures, thus causing a maximum number of complications [10]. There are sporadic studies devoted to analysis of chemical ingredients in tattoo pigments of different colors. Thus, J.M. Sowden and D. Slater with coauthors studied a red pigment using light and electron microscopy combined with X-ray microanalysis and determined that this dye contained aluminium, iron, titanium, silicon, calcium, mercury, and cadmium, which could cause various complications [11, 12].

Compositions of tattoo pigments depending on the color spectrum are presented in Table 1 [13, 14].

Besides toxic substances containing in the composition of pigments used for tattooing, some researchers found compounds exhibiting a pronounced mutagenic and carcinogenic activity (Table 2).

During the analyses, we have noted that the most common complications are such allergic reactions as urticaria (3%), contact dermatitis (19.9%), eczema (7%), and anaphylactic reaction (0.1%). Moreover, there were cases of HIV (3%) and hepatitis (8%) infection. Secondary infection was observed in 15% of cases.

Side effects were characterized by a pronounced polymorphism (purulent-inflammatory, degenerative, necrotic, and neoplastic processes).

Clinical Cases

As an example, we describe several clinical cases, which we observed while developing this problem.

Female patient A., 24 years old, applied to Moscow Scientific and Practical Center of Dermatovenereology and Cosmetology of the Department of Healthcare of Moscow in March of 2016 and complained about papulous lesions arising from a tattoo, itching, urtication, feeling of skin tightness. The tattoo was done 6 month ago and underwent the following changes within 1-2 months: it became red and papulous. The physical examination showed a satisfactory condition of the patient, no changes in the internal organs and systems were detected. *Status localis:* a sclerotic, reddened scar in the form of a dragon with inclusions of blue-black pigment, with a smooth surface, with some protuberances was detected on the back skin. The scar was indurated and pain-free on palpation (**Fig. 1**). A puncture biopsy was performed, the skin biopsy specimen showed uneven distribution of pigment immediately under the epidermis in the papillary dermis, with a wide range of granule size: from separate well-distinguished granules of pigment to "dust-like". In some areas there was no pigment, but there were changes in fibers of connective tissue, which were thickened in comparison with other fibers of dermis and were in the form of homogeneous pink fiber masses (**Fig. 2**).

Table 1. Composition of tattoo pigments depending on the color spectrum and possible complications after tattoo procedure

Tattoo ink/ pigment color	Pigment composition	Notes
Black	Fe ₂ O ₃ , C, <i>Haematoxylum campechianum</i> (campeachy wood)	Natural black pigment made of magnetite crystals, carbon black. Campeachy wood (bloodwood tree). A species of a flowering tree in the legume family <i>Haematoxylum</i> genus, Caesalpinioideae subfamily, is used to produce hematoxylin stain. The majority of non professional tattoos are done with the black pigment, which is natural, in this connection tattoo complications are exceedingly rare [15].
Yellow	Cadmium yellow, ochre, curcuma, chrome yellow (PbCrO ₄ often mixed with PbS)	Tattoos with yellow pigment cause complications rarely, in the form of local reactions: swelling and erythemas, photoallergic reactions due to cadmium sulfide, which is a photosensitive material [16].
Red	HgS (mercury sulfide, cinnabar), cadmium red, Fe ₃ O ₄ , naphthol-AS (azotol)	There are often complications caused by red pigments containing such components as mercury sulfide (cinnabar) and cadmium pigments exhibiting pronounced toxicity [17]. In 1976, The Food and Drug Administration limited mercury ratio in tattoo to 3x10 ⁻⁶ (3 ppm). The most common are lichenoid reactions [18, 19].
Brown	Fe ₃ O ₄ , Fe ₂ O ₃ xH ₂ O	The pigment consists of iron oxides mixed with clay. When heated, ochre changes its color from yellow to reddish. Complications are rare [20].
Green	Cr ₂ O ₃ , PbCrO ₄ , ferrocyanides, ferricyanides (of potassium, iron), and cobalt chloride	Allergies to green and light-blue pigments are rare, and they are caused by chromium, aluminium or cobalt chloride [21]. Chromium causes local eczematous reactions, hand eczema, and generalized eczematous damages [22]. There are references to a development of chronic dermatitis in the area of a tattoo with green pigments, in this case all the patients had a positive reaction to 0.25% potassium dichromate in vaseline [23].
Blue	Copper carbonate, sodium aluminosilicate (lapis lazuli), copper calcium silicate (Egyptian blue), other cobalt aluminates and chromium oxides	Blue mineral pigments are the least likely to cause complications, the following side effects are possible: allergic reaction due to individual sensitivity. There is described an individual case of the development of systemic sarcoidosis as a reaction of a delayed-type hypersensitivity reaction [24, 25, 26].
Violet	Ammonium manganese sulfate, pyrophosphate, dioxazine / carbazole	Some violet pigments, especially bright purple, are photoreactive and lose color after a long expose to light. Aseptic granulomatous inflammation was described as a possible complication [27].
White	White lead carbonate, titanium dioxide, barium sulfate, zinc oxide	Titanium oxides are the less reactive white pigments without described side effects.
Henna	Paraphenylenediamine (PPD)	Henna tattoos are temporary and the safest. Only local contact dermatitis is a possible complication [28–30].

Table 2. Mutagenic and carcinogenic components of tattoo pigments

Substance	Reference
Mercury	31
Monoazopigment	32, 33
Disazodiarylide, naphthol AS-pigment, aluminium, quinacridone, dioxazine, Cu-phthalocyanine	34, 35
Naphthol AS-AS	36
Carbon black	37, 38
2-methyl-5-nitroanilin, 4-nitro-toluene, 2-5-dichloroaniline	39
Phenol	37
Titanium dioxide	34, 35
Hexachloro-1,3-butadiene, methenamine, dibenzofuran, 1,2,3,4-tetrahydro-1-phenyl-naphthalene	36, 40

The final clinical diagnosis was a keloid scar (L91.0). Laser therapy is ineffective for this diagnosis, so an intralesional diprosan injection was recommended to the patient. A limited clinical improvement was observed on the top of already administered therapy.

Female patient H., 23 years old, applied to Moscow Scientific and Practical Center of Dermatovenerology and Cosmetology of the Department of Healthcare of Moscow in May 2017 and complained about the changes in the

appearance of the tattoo, skin sloughing in the red tattooed area, and skin itching. The patient noticed the appearance of disease 2 months after the tattoo procedure, she received glucocorticosteroid and antihistamine treatment, but without any improvement. The physical examination showed a satisfactory condition of the patient, no changes in the internal organs and systems were detected.

Status localis: dryness of the skin is observed in the red tattooed and surrounding areas of the skin, skin indura-



Fig. 1. Six-months-old tattoo at the scapula with keloid transformation phenomena.

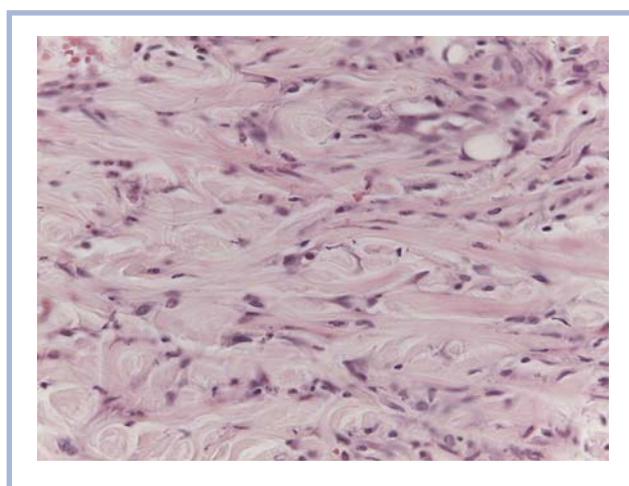


Fig. 2. Skin fragment obtained by puncture biopsy. Severe lymphocytic infiltration, homogenized immature eosinophilic fibers. Structureless dermal fibers. Hematoxylin and eosin stain. magnification $\times 400$.

tion, macrolamellar sloughing, single large vesicular and bullous elements were detected on the surface in the focus of a disease (**Fig. 3**).

A histological examination revealed atrophic changes in the epidermis, smoothing of its papillae on the background of a pronounced hyperkeratosis and acanthosis. Moreover, areas of papillomatosis were observed. Granules of pigment were diffusively distributed in the dermis, but there was no lymphohistiocytic infiltration. A pronounced swelling caused the undermining of adjacent dermis from epidermis in some areas, thus forming fissulas, which morphologically corresponds to lichen ruber planus pemphigoides (**Fig. 4**). The final clinical diagnosis was: other lichen ruber planus (L43.8). The following treatment was prescribed to the patient: intralesional diprospan injection, topical corticosteroids, reducing agents. The rash regression was 70% in 2 months on the top of already administered therapy.

The tattoo complications detected by us were compared with the literature data and presented in Table 3.

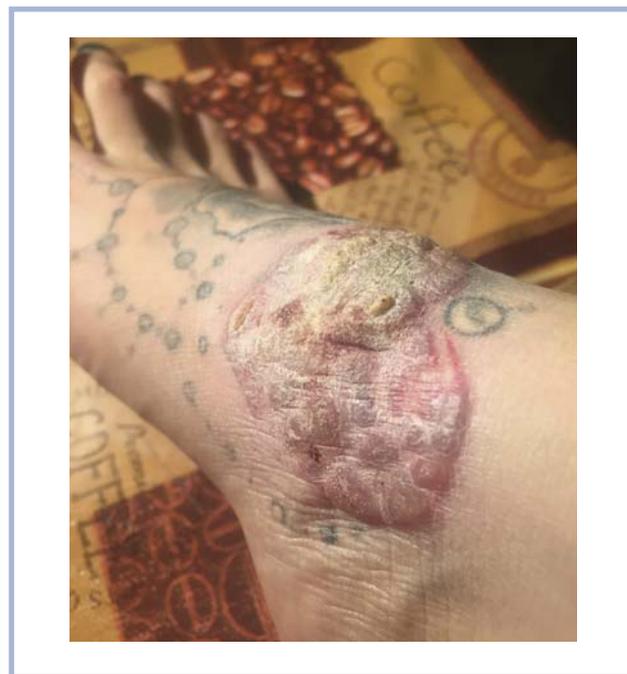


Fig. 3. Decorative tattoo on the dorsum of the foot. Change in the appearance of the tattoo, skin induration at the area of red pigment, vesicular and bullous elements, lamellar sloughing.

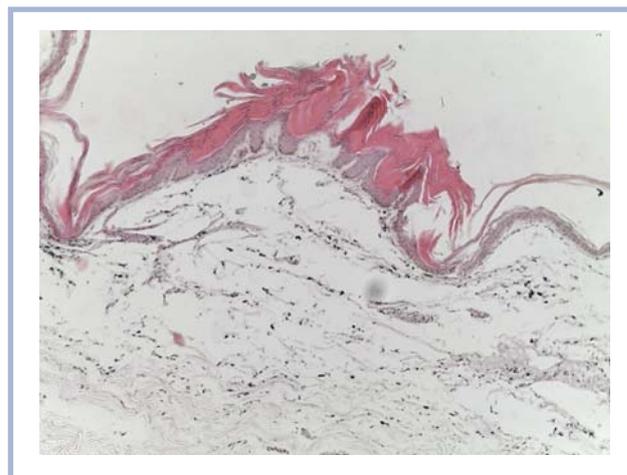


Fig. 4. Skin fragment with massive hyperkeratosis at the tattooed site, acanthosis, and areas of papillomatosis. Diffuse pigment distribution, pronounced swelling. Hematoxylin and eosin stain.

Tattoo-caused complications can be roughly divided into local (in the immediate area of tattoo) and systemic complications (pathologic processes developing due to the execution of a tattoo manipulation). In terms of the onset of appearance, it is reasonable to distinguish complications, which develop immediately during the procedure execution and delayed. Immediate side effects are often characterized by allergic reactions, because pigment is a foreign antigen, and depending on the immune responsiveness of an organism the reaction to its insertion is in-

Table 3. Tattoo complications and the incidence of adverse reactions.

Types of complications	Clinical manifestations	The incidence, %	Onset of appearance	Localization of tattoos	Cause of appearance	Diagnostics	Treatment	Reference
Allergic reactions	Allergic dermatitis; photoallergic reactions; urticaria; anaphylactic shock	30	During the procedure, first few days, after the contact with UV radiation	At any area of the body, more often on the trunk, on extremities	Type IV hypersensitivity reaction, pigment accumulation	Allergy testing	Antihistaminic drugs, hyposensitization therapy, laser therapy	41, 42
Infectious complications	Bacterial: sacred fire; syphilis; sepsis; gangrene; pyoderma; dysbacteriosis. Viral: HIV; hepatitis B, C; D; contagiosum epitheliale. Mycoses: dermatomycosis.	15	Few days to weeks	At any area of the body, more often on extremities	Infected pigments, infected tools	Bacteriologic examination	Antibiotic drugs	43, 44, 45, 46, 47
Granulomatous inflammation	Nonspecific foreign body granulomatous aseptic inflammation (pigment). Nonspecific foreign body granulomatous aseptic inflammation with lymphadenopathy. Skin manifestations of sarcoidosis.	11	Weeks to months			EIA, PCR	Antiviral drugs	
		12				Bacteriologic examination	Antifungal drugs	
		35	Months to years	At any area of the body, often after permanent makeup	Nonspecific foreign body granulomatous aseptic inflammation	Histologic examination	Steroid antiinflammatory drugs, laser therapy	48, 49, 50, 51
Tumors and tumor-like masses	Dermatofibroma. Pigmented (melanocytic) naevus. Melanoma. Squamous cell skin cancer. Keratoacanthoma.	10	Over the course of several years	At any area of the body	Traumatic skin injury with a needle, cancerogenes in pigment composition	Histologic examination	Surgical treatment, radiation treatment	52, 53, 54, 55, 56, 57, 58
Local skin diseases	Lichen ruber planus. Keloid. Lichenoid.	27	Weeks to months	At any area of the body, more often on the trunk, on extremities	Autoimmune responses, traumatic skin injury with a needle	Histologic examination, bacteriologic examination, immuno-fluorescence tests	Surgical treatment, laser therapy	59, 60, 61, 62.

dividual, up to the development of anaphylactic shock, as well as infectious reactions caused by the violation of sanitary-hygienic standards during the procedure. Delayed tattoo complications could be subdivided into early-delayed complications, if their first manifestations are recorded up to 4 weeks, and late-delayed complications, if their first manifestations are recorded after 4 weeks.

Depending on the etiology, tattoo complications could be divided into infectious and aseptic. At the same time, it should be mentioned that this side effect is not always caused by violation of the procedure technique, but largely depends on individual microflora of a client, whose skin could be initially colonized with pathogenic pyogenic microorganisms, which penetrate in the tattoo zone during the moment of the manipulation and after it.

On the basis of the carried out studies aimed to systemize the available data on tattoo-caused side effects, we would propose the following classification of tattoo complications.

Classification of tattoo complications

In terms of prevalence

I. Systemic — systemic sarcoidosis (D86), HIV infection (B20), hepatitis B (B16), C, D (B17), lichen ruber planus (L43).

II. Local — contact dermatitis (L25), keloid scar (L91.0).

In terms of the onset of appearance

I. Immediate — arisen during the tattoo procedure execution: anaphylactic shock (T78.2).

II. Delayed:

1) early-delayed tattoo complications — pyoderma (L08.0);

2) late-delayed tattoo complications — nonspecific granulomatous aseptic inflammation around a foreign body (pigment) (L92.0-L92.9); neoplasms, sun sensitization.

In terms of etiology

I. Infectious:

1) bacterial — pyoderma (L08.0), staphylococcal skin injury in the form of burn-like blisters; pyogenic granuloma (L98);

2) viral — hepatitis B (B16), C, D (B17); HIV infection (B20); parenterally transmitted infections;

3) fungal (mycoses);

4) dysbacteriosis.

II. Allergic reactions:

1) urticaria (L50);

2) allergic contact dermatitis (L23);

3) unspecified contact dermatitis (L25);

3) anaphylactic shock (T78.2).

III. Granulomatous reactions:

1) nonspecific granulomatous aseptic inflammation around a foreign body (pigment) (L92.0-L92.9);

2) nonspecific granulomatous aseptic inflammation around a foreign body (pigment) with lymphadenopathy (L92.0-L92.9);

2) sarcoidosis of skin (D86.3).

IV. Tumors and tumor-like masses:

1) keloid (L91.0);

2) dermatofibroma (D23);

3) pigmented (melanocytic) naevus (D22).

Conclusion

Thus, despite the absence of well-defined contraindications to tattoo procedures, in some concrete clinical cases tattoos could cause the development of serious diseases, so a further study of this problem with the aim of prevention of complications and optimization of disease management is required.

Taking into account the invasive character of procedures and a large number of complications, it is necessary:

1. to elaborate a list of contraindications for tattoo procedures;

2. to determine a problem for the competent government institutions with the aim of mandatory certification of tattoo pigments and work place of a tattoo master;

3. to elaborate a standard of preliminary laboratory investigations, preceding this invasive procedure (allergy test with the pigments used for tattoo, bacterial inoculation for flora on the area of a potential tattoo, etc.);

3. to increase requirements to tattoo specialists (medical degree, certificate of primary accreditation of specialists with a tattoo master qualification).

Authors' contributions:

The concept and design of the study — A.A. Vorobiev

Collecting and interpreting the data — O.N. Karymov

Statistical analysis — O.N. Karymov

Drafting the manuscript — S.A. Kalashnikova

Revising the manuscript — A.A. Vorobiev

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