

Frequently asked questions regarding the expertise conducted on President Yasser Arafat's personal belongings and remains

1. Purpose of this document

The purpose of this document is to clarify the position of the Centre Universitaire Romand de Médecine Légale - CURML (University Center of Legal Medicine, Lausanne-Geneva) and the Institut de Radiophysique - IRA (University Institute for Radiation Physics) following the expertise conducted in connection to the possible causes of the death of President Yasser Arafat.

2. Origin of the procedure

Why was the expertise requested such a long time after the death?

- We are unable to respond to this question; we became involved for the first time toward the end of 2011.

What were the requests and who made these requests?

- In December 2011, Mrs. Suha Arafat contacted us via Mr. Clayton Swisher, a journalist working for Al Jazeera, and gave us a mandate to analyze the personal belongings contained in a sports bag that President Yasser Arafat had with him at the Percy military hospital where he died. The report was given to Mrs. Arafat in June 2012.
- Following the publication of these first results within the framework of an Al Jazeera news story, we were also mandated by the Palestinian National Authority (PNA) in October 2012 to continue these investigations, notably following the exhumation of Yasser Arafat's remains which took place on 27 November 2012. The report was delivered to the PNA on 5 November 2013.

Why was this case dealt with in Lausanne?

- The Centre Hospitalier Universitaire Vaudois (CHUV - Lausanne University Hospital) is one of the only locations to house both a University Center for Forensic Medicine (CURML) and an Institute of Radiation Physics (IRA).
- The CURML is highly regarded for its international investigations, especially in the Middle East.
- IRA is well recognized for its work measuring radioactive substances in the environment and in human remains.
- Switzerland's neutrality was also perhaps perceived as an advantage in the context of this case.
- All accessible medical files were written in French.

Who financed the analyses?

- We billed our work in equal parts to Mrs. Arafat (first series of analyses, those conducted on Arafat's personal belongings) and to the Palestinian National Authority (second series of analyses, the samples removed during the exhumation).
- The rate applied was the officially recognized billing rate in Switzerland (TARMED medical billing system)
- Al Jazeera did not contribute financially to the project, in either case.

Were you able to work completely independently?

- We were not subject to any pressure. No one—not the political authorities, nor the hospital or university management—was involved in the production and communication of our results.

3. Medical Aspects

What were Yasser Arafat's initial symptoms?

- Approximately 4 hours after supper on 12 October 2004, Yasser Arafat experienced serious digestive problems combining nausea, vomiting, and abdominal pain, followed by watery diarrhea without a fever.

What was the cause of these initial symptoms?

- We were granted access to the medical report made at Percy Hospital, which is well documented. This report concluded that despite consulting with numerous medical experts and conducting multiple investigations, the pathophysiological mechanism at the origin of these symptoms could not be identified.

What was the cause of death?

- Yasser Arafat died of an intracerebral hemorrhage related to clotting problems that developed following the first digestive symptoms which appeared on 12 October 2004. In this sense, although the immediate cause of death was clearly established, this was not the case for the initial symptoms that led to the later development of the clinical picture surrounding his death.

What are the symptoms of polonium poisoning?

- Because of its radiological properties, polonium is a very dangerous radioactive element. As it disintegrates, it emits alpha particles which produce particularly harmful ionisations because of how easily they are absorbed at a short range. The daughter product of polonium-210 is lead-206, which is a stable (not radioactive) and naturally-occurring (easily found in nature) element.
- There are very few documented cases of polonium-210 poisoning (either through ingestion or inhalation). One notable case was that of Alexander Litvinenko in 2006. Most of our knowledge comes from animal experiments conducted in the 1950s and 1960s (mice, rats, rabbits, and dogs).
- It is important to note that when speaking of *acute radiation syndrome* this is generally in reference to external irradiation situations in which all organs receive a nearly identical dose. In the case of poisoning through polonium ingestion, the element is distributed throughout the body beginning with the digestive system and then via blood circulation to the rest of the body. Approximately 90% of the ingested activity is eliminated through stool while the rest tends to accumulate first in the kidneys and the liver, and to a lesser degree along the surface of the bones. Because alpha particles do not travel far, the exact location of the polonium atoms during this pharmacokinetic process directly determines symptoms. This means that the cells situated only a few dozen micrometers away are not affected by the alpha radiation. Recent research concerning medical treatments with radium-223 (which is an alpha-emitter like polonium) shows that effects on blood count and hair vary broadly from patient to patient.
- Despite these large uncertainties, it is generally understood that polonium-210 poisoning through ingestion leads first to digestive difficulties and second to bone marrow damage, liver and kidney malfunction and, in a less documented way, to hair loss from both the head and the body. Nonetheless, one cannot exclude the possibility of a staggered poisoning in which a repeated but smaller dose is ingested over time as opposed to the case of an acute

poisoning. Within this hypothesis, the clinical picture experienced in the acute poisoning may be different and essentially indicated by digestive symptoms similar to what the various animal studies have shown.

How is a case of acute polonium poisoning diagnosed?

- For someone who has ingested a large activity of polonium-210, the alpha emissions in biological samples (urine, stool, blood) can be measured with an appropriate instrument. If the measurement is not taken with a suitable detector, there is little chance of detecting the polonium. In the case of Litvinenko's poisoning, the polonium was only identified the day of his death¹.

Was an autopsy performed following the death of Yasser Arafat at Percy Hospital?

- Despite the prominence of the person involved and the uncertainties concerning his clinical manifestations, an autopsy was not performed and we do not know the reasons for this decision.

4. Generalizations about the measurements conducted

Did we analyze the same samples as the other laboratories?

- To our knowledge, we are the only ones to have analyzed Yasser Arafat's personal belongings, the items kept after his stay in Percy Hospital.
- We are the only ones to have conducted a direct measurement of the radon in the tomb before it was opened.
- We are the only ones to have measured the surface activity of the soil inside the tomb, on the scalp, on a flat bone (the iliac crest) and on the shroud in order to evaluate the extent of the radon deposits.
- Following the exhumation, which involved three teams (Russian, French and Swiss) and was led by a Palestinian medical examiner, each team received biological samples of a similar nature and in equivalent quantities. According to the respective reports, the Russian team measured 25 samples, the Swiss team measured 16, and the French team measured 5 (see Figure, Section 6 below).

Why was the decision made to exhume the body?

- Because there had been no autopsy investigation performed after President Arafat's death.
- Our measurements on Yasser Arafat's personal belongings revealed abnormally high quantities of unsupported polonium on the samples bearing stains from biological fluids (urine, saliva, blood, sweat).
- These measurements alone did not make it possible to conclude with certainty upon the poisoning hypothesis and so we suggested taking measurements on Yasser Arafat's remains in order to verify if any polonium-210 might be present in his body.

Are we sure in terms of the origin of the samples?

- DNA tests were conducted on Yasser Arafat's belongings and on his remains, and compared to the DNA profiles of his wife and daughter. We were able to confirm that the samples came from Yasser Arafat.

¹ This point has been corrected following the publication of the Owen report and a message from Mr David Marin (Radio télévision suisse). We mistakenly reported in an earlier version of the present text that polonium was identified *four days before his death*.

Did we look for other poisons or toxic substances?

- Yes, a traditional toxicological analysis was conducted using mass spectrometry (medicines, pesticides, metals, etc); first upon Arafat's personal belongings and second on the samples removed from his remains. These tests only revealed the medicines administered during his hospitalization.

Is polonium a natural element?

- Polonium is naturally present in low quantities in the environment and in living organisms. It is a part of the uranium decay chain, along with radium and radon, for example.

What is the link between radon and polonium?

- Radon gas occurs naturally in the environment. Radon is the result of the radioactive decay of radium-226, which is itself a product of uranium-238 decay, present in the earth's crust at the time of its formation.
- Radon is radioactive and leads to the production of a great quantity of radioelements including lead-210 and polonium-210.
- In this way, radon accounts for naturally-occurring lead-210 and polonium-210 in the environment and living organisms. As a general rule, these two elements are found in equal quantities (in terms of activity) and in this case we say that the polonium is *supported* by the lead-210. It is important to note the differences of decay time between these two radioelements: polonium-210: 138 days; lead-210: 22 years.

How does someone obtain artificial polonium?

- Artificial polonium is produced in nuclear reactors. A recently manufactured source of artificial polonium-210 does not contain a significant quantity of lead-210. In this case the polonium is considered to be *unsupported* by the lead-210.

Can someone easily acquire a lethal quantity of polonium and how much does this cost?

- Polonium-210 is a highly toxic product and its use is subject to very strict monitoring by the authorities involved. At the beginning of the nuclear era, it was used as a detonator (*trigger*) of atomic bombs.
- A lethal quantity of polonium requires special authorisation and is expensive to buy.

5. Radio-toxicological measurements conducted

What kind of radio-toxicological measurements were taken during President Arafat's stay in Percy Hospital?

- According to the hospital's 2004 medical report, two urine samples were analyzed with gamma spectrometry several days before his death. No abnormal quantity of any gamma-emitting radioelement was detected.
- We were able to obtain the raw data from the gamma spectrums in April 2012; our goal was to analyze the possible presence of polonium. Nevertheless, the high detection limit for this measurement meant we could not detect any polonium-210.
- To our knowledge, no tests were conducted for any alpha-emitters (like polonium-210) while President Arafat was at Percy Hospital.

Why didn't the forensic investigation deal with the same biological samples as those investigated at the time of Arafat's stay at Percy Hospital?

- For the simple reason that we were told by the French authorities that all the samples were destroyed several years after Yasser Arafat's death.

Why did we think of polonium?

- Because of the lack of a physiopathological explanation to the developed symptoms, including a poisoning, the hypothesis of poisoning by radioelement was suggested and a radiotoxicological analysis conducted. Note, however, that the hypothesis of a poisoning by radioelement was considered by the doctors at Percy Hospital, who did conduct a radio-toxicological analysis via a laboratory at the Ministry of Armed Forces.
- The urine tests conducted using gamma spectrometry, however, were negative. Remember that an alpha-emitter test was not conducted. And polonium emits alpha radiation.
- It was only following the polonium poisoning case of Alexander Litvinenko in 2006 that the use of this element as a poison was first documented. When we were contacted in 2012, any laboratory conducting radio-toxicological testing would have suggested measuring for polonium.
- Note that Yasser Arafat's urine samples were destroyed in France after the Litvinenko case, and without their being officially tested for polonium.

What is our experience in terms of polonium analysis?

- Following the Litvinenko case, we developed a method of measuring this element in order to investigate the urine samples of Swiss citizens having stayed in London near the locations where the events took place in 2006.
- Furthermore, our laboratory is experienced in testing bone samples for strontium-90, lead-210 and polonium-210 within the context of dating these samples for forensic medicine use.

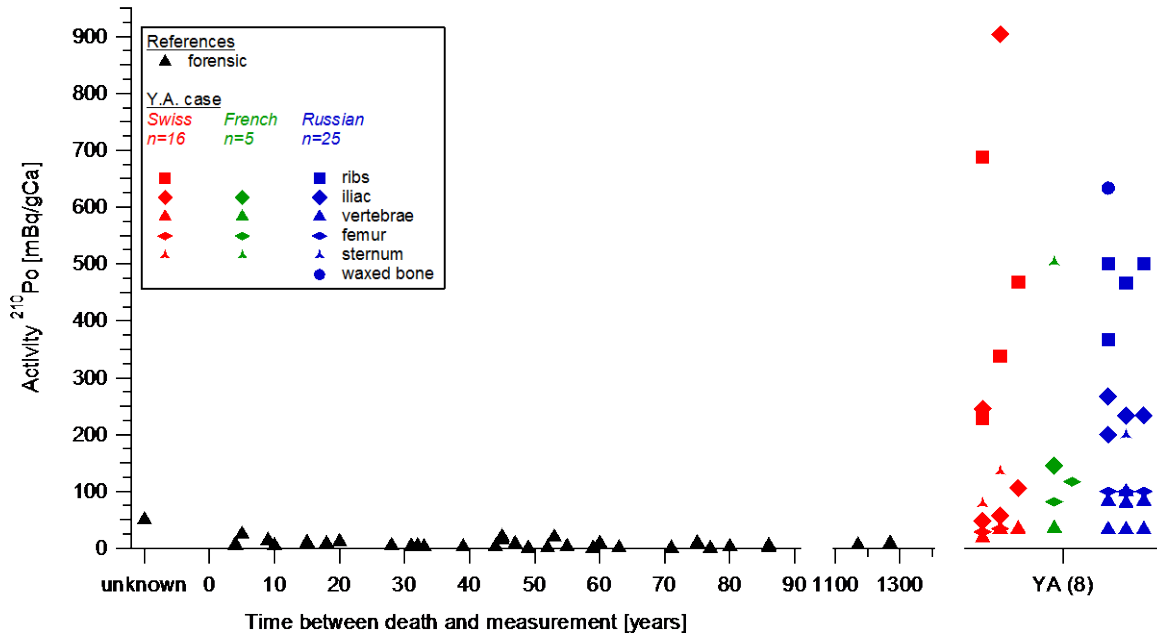
How would measuring a commercial source of polonium be useful in the context of this affair?

- Yasser Arafat's bones contain abnormally high and unexplained levels of polonium-210 and lead-210. After having acquired a commercial source of polonium-210, we measured a significant activity of lead-210 inside. Our calculations show that the presence of this lead-210 impurity can explain the results obtained in Yasser Arafat's bones.

6. Conclusions of the analytical reports

Were the results of the analyses coherent between the different laboratories?

- Only the Swiss laboratory investigated Yasser Arafat's personal belongings, which were gathered and kept by his wife following his death at Percy Hospital.
- The three laboratories (Russian, French and Swiss) measured polonium-210 and lead-210 activities which were similar and significantly higher than those described in the scientific literature. As shown in the figure below, the activities measured in bones taken from forensic cases for dating times of death are all less than 50 mBq/gCa while the activities measured in Yasser Arafat's (YA) bones are much higher, even reaching several hundred mBq/gCa. Note that the French laboratory only analyzed 5 samples (compared to 16 for the Swiss and 25 for the Russians) and that it did not analyze the samples taken from the ribs which revealed the highest numbers.



Can the presence of polonium-210 and lead-210 in Yasser Arafat's bones be explained by the presence of radon in his tomb?

- The radon in the tomb is not enough to explain the concentrations of polonium-210 and lead-210 measured in the bones.
- In order to minimize the radon deposits coming from the immediate environment of the tomb and to measure what could have been incorporated by President Arafat while still alive, each laboratory followed a one- or multiple-step procedure to decontaminate the bone surfaces.
- Our laboratory was the only one that measured the radon concentration inside the tomb. The value measured, $12,000 \text{ Bq/m}^3$, can be considered low. Furthermore, the forensic analysis cases presented in the figure above also come from environments potentially high in radon. And yet the analyses do not reveal a significant lead-210 and polonium-210 contamination in these cases. The presence of radon cannot then be considered a cause of the excess of polonium-210 observed in Yasser Arafat's bones.
- Note that we looked to evaluate the implication of radon on the concentrations of polonium-210 measured. To this end, we made a comparative analysis of the scalp with different specimens of the shroud that covered it. If the radon was the exclusive cause of the polonium-210 concentrations measured, we would have measured equivalent activities of this radioelement on both the shroud and the scalp, which was not the case. Indeed, the concentrations of polonium-210 measured in the scalp were 11 to 33 times higher.
- Two soil samples were tested: one located in the corner of the tomb the farthest from the remains (reference) and the other beneath the abdominal cavity and by all evidence contaminated by biological fluids. Here as well, we would have expected the surface activities to be similar if the radon were the cause of the high values measured. But in actuality, the soil situated beneath the abdomen contained approximately 17 times more activity than the reference soil sample.

Why can't our conclusions be more affirmative?

- Because of the uncommon nature of the samples analyzed (personal effects, decomposed biological samples, etc.) and the 8 years between the death and the analysis, in consideration of the short decay period of polonium-210.
- Because of not identifying unsupported polonium in the samples coming from the exhumation, which meant we were unable to conclude with certainty that the death was the result of poisoning with this radioelement.

Can we exclude other types of poisoning?

- It is impossible to even consider being able to analyze all potential toxic substances. In this sense it is possible that another substance which was not tested while President Arafat was still alive or after the exhumation, or one that was tested for but had already been eliminated from his body might be the cause of the symptoms that led to his death.

7. Conclusions

Why did we use a Bayesian analysis and why doesn't the conclusion estimate the probability that Mr. Arafat was poisoned by polonium?

- Each observation taken individually makes it impossible to determine the cause of death with certainty.
- Bayesian analysis is a commonly used tool in forensic science and especially since it was introduced by the French mathematician Henri Poincaré in the Dreyfus affair more than a century ago. This tool makes it possible to consider an array of observations within their context by determining a "likelihood ratio" for each. In our case, we considered all the observations with the hypothesis of polonium poisoning on the one hand and with the hypothesis of another unknown cause on the other hand. This allowed us to conclude that, within the hypothesis of polonium poisoning, all our observations were more coherent than within the alternative hypothesis, according to which the involved party would not have been poisoned by polonium.
- This brought us then to formulate our conclusion in this way: **"our results moderately support the proposition according to which the death was the result of a polonium-210 poisoning"**.
- In this sense, these results do not then define the probability to which Yasser Arafat would have been poisoned by polonium, but must be integrated into the larger context of the police and legal investigations in connection to this case, and which are beyond our field of expertise.

Will we know the truth one day?

- Unfortunately, it is likely that we will never know the truth of this case. We do believe, however, that we used our analytical capacities within our field of expertise to their fullest extent. For a definitive conclusion, other sources of information must be gathered and integrated into the scientific data.

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