Drug Analysis as a basic for driving ability examination

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In accordance with the report "Krankheit und Kraftverkehr" illegal drug addiction can lead to a declaration of ineligibility to drive a motor vehicle. For this reason proof through chemical analysis has increased in importance. In this report even the regular consumption of an illegal drug is sufficient to prevent the abuser from being issued a driving licence.

In criminal court proceedings the consumption of an illegal drug must be proved. Contrary to this, the Driving Licence Authorities simply require an indication of illegal drug abuse to order a medical-psychological examination. In spite of this the chemical findings should be as well supported scientifically as in criminal court proceedings.

In court proceedings where our institute has been appointed the main expert it has often been the case that initially only immunological examinations of urine samples have evidential value during the various stages of court appeal. Legal pathologists and forensic toxicologists, and not forgetting Prof. Machata, have always stressed the importance of supporting chemical examinations with a second independent method. Immunological findings can only offer an indication of illegal drug abuse.

Alongside the general failure rate through matrix effects, immunological methods, when dealing with opiates cannot distinguish between heroin consumption and the intake of codeine or RemedacenR. Immunological examinations must therefore always be supported by chromatographical examinations, and best of all by using a mass spectrometer.

With opiates, heroin consumption can only be proved through the determination of the concentration relations of morphine and codeine or through the detection of monoacetylmorphine or heroin itself. But even the use of modern technical instruments in a urine examination can only detect the intake, and does not allow a statement regarding the dosage. Even this detection of an intake of the major illegal drugs, heroin, cocaine, THC, is only made indirectly through the determination of the metabolites.
A positive urine sample coincidentally comes from a concentration point on this curve, illustrated here by the arrows. This does not allow any inference regarding the area, or the amount of drug eliminated, or even the dosage. The total time interval involved amounts to only a few days.

If proof of a regular drug consumption is required, then samples must be taken weekly.

The situation with the hair is different. The hairs grow about 1 cm a month and receive traces of the illegal drug through the hair roots. They generally retain the drug at the point in the hair where it was absorbed.

It is therefore possible to create a picture of the total time interval of elimination, in comparison to a urine sample collected during the whole time of elimination.

We now compare the elimination of a single dosage with a picture representing the observation period of a hair tuft. We usually examine 3 cm long hair sections. Healthy hairs grow at a rate of between 0.8 and 1.3 - approximately 1 cm a month. The elimination pattern of a single dosage lies within the total area being measured and is approximately 1 mm long.
It cannot always be guaranteed that single dosages are detected, but it is generally the case that the illegal drug has been consumed more than once. In the distribution pattern it looks something like in figure 3:

These pictures suggest it is possible to differentiate between regular and occasional consumption. It is a disadvantage that - for obvious reasons - tests cannot be carried out on humans to find the concentrations in hair following heavy illegal
drug consumption. However we know from experiments with medication in therapeutical dosages that there is a dosage - concentration correlation. To determine whether the illegal drug consumption was regular or not we can use comparisons with other hair analysis from drug addicts. It is now up to the medical-psychological examination authorities to draw the appropriate conclusions regarding driving ability.

The most important illegal drugs that we have experiences with are opiates, cocaine and cannabinoids. We still do not have enough experience to draw direct conclusions about driving ability from concentrations of cocaine and the cannabinoids.

With cocaine the extreme variation in the amount of intake leads also to a very wide span in concentration levels - based on our experience up to 500 ng/mg of cocaine. With cannabinoids in Ulm we have not reached a final decision yet whether THC itself, cannabinol or the metabolite carboxy-THC should be made the basis of the quantitative evaluation. We have the most experience with the quantitative determination of opiates, which we have been carrying out since 1985.

**Codeine Substitution**

![Codeine Substitution Chart](image)

*Fig. 4: Distribution of opiates in hair after heroin substitution by codeine*
Here are some examples to demonstrate the advantages of hair analysis. In one case a woman was spotted driving erratically. Suspected of drunken driving she was administered a blood alcohol test which turned out to be negative. The blood sample was then examined for illegal drugs. The only findings were therapeutical concentrations of codeine. In this case the accused had already stated that she was on medication. However there was no medication containing codeine on the list she had provided.

Since codeine is very often used by addicts as an alternative a hair analysis was carried out. Here we can see clearly that mainly codeine was consumed during the growth phase of the last segment. In the sections before this however a ratio of morphine and codeine was detected which is typical of a heroin abuser (Fig.4). Correspondingly this information was forwarded to the Driving Licence Authorities.

In the next case we can clearly see the substitution with dihydrocodeine. In the older hair sections opiates typical of heroin abusers were found; mainly dihydrocodeine was found in the sections near the hair roots (Fig.5).

![Dihydrocodeine Substitution](image)

Fig. 5: Distribution of opiates in hair after heroin substitution by dihydrocodeine
Fig. 6: Typical concentrations in hair of heroin addicts

What concentrations do we usually find with heroin abusers?

A typical distribution following the hair analysis of a normal heroin abuser looks something like this:

Monoacetylmorphine concentrations and morphine concentrations of between 1 and 10 ng/mg; codeine concentrations amounting to approximately 1/10 to 1/5 - or 10 to 20% - of the morphine concentrations.

On the basis of over 800 segments that have been examined for morphine derivatives by Prof. Möller in Homburg/Saar and by our laboratory, we know that with a detection limit of approximately 50 picogramme/mg morphine the median morphine concentration lies around 2 - 5 ng/mg. Maximum concentrations in this time period of examination lay at 50 ng/mg. Following a series of examinations of drug fatalities we know that morphine and monoacetylmorphine concentrations of over 100 ng/mg also exist.

The experience with heroin abusers has shown that there are only very few abusers who take heroin occasionally. A normal consumption level may be said to
correspond to the definition of regular consumption in the "Krankheit und Kraftverkehr" report:

With findings where there is a concentration of over 2 ng/mg of morphine, monoacetylmorphine and heroin in hair segments with a total length of over 6 cm, we assume therefore that regular consumption has taken place.

At this point we should discuss the dangers of the misinterpretation of analysis results. Unfortunately hair does not grow as uniformly as we would prefer for the interpretation of the results. Hair grows about 4-6 years and enters a stagnation phase of 4-6 months before it falls out.

This means that the substance is not to be found at the same place in all hairs.

Theoretically therefore the substance must distribute itself in a hair tuft. This effect can be seen in the diagram: the red lines represent hairs containing illegal drugs; the green lines hairs free of drugs. This effect would not bother us too much if we were dealing with single dosages. This would not influence the evaluation of the findings.

In other cases this effect can lead to absolutely false evaluations.

Fig. 8 represents a theoretical case where a drug abuse was totally stopped. We see at 180 days that the borderline between the red and green segments is not
smooth. Also in the time periods corresponding to growth after the end of the drug consumption there must still be illegal drugs in the stagnating hair. More exact calculations using the average growth and stagnation phases reveal that up to 10% of the original concentration can still be found in hair sections corresponding to the period when there was no drug consumption. In Fig. 8 this means that in the first segment to the left of the 180 days mark the number of red segments are 10% decreasing to none in the direction of the hair root.

![Diagram showing the distribution of drugs after the end of frequent drug abuse.](image)

Fig. 8: Theoretical distribution of drugs after the end of frequent drug abuse
(spotted line: drug free)

The following is possible:

A test person with his hair less than 6 cm long states that he has not consumed any opiates in the previous 6 months. An examination reveals 2 ng/mg morphine. Initially this person would have been placed in the average heroin consumer category. The illustration shows however, that these substances could have come from an intensive consumption which led to concentrations of over 20 ng/mg in hair sections but which are no longer at our disposal.

In hair analysis, as opposed to urine samples, great care must be taken to ensure that the results allow an accurate evaluation. The neat looking distributions in the diagrams with the concentration distributions may hide the fact that sampling was
not conducted properly. Due to the different phases in hair growth mentioned earlier there is no point in trying to use as small a hair sample as possible. There must be a guarantee that the sample is representative and that the results can be used for comparative purposes.

In cooperation with law enforcement agencies the following arrangement was agreed upon:

A hair tuft, about as thick as a pencil, should be cut from the back of the head, after it has been tied with a piece of string. After being cut this is then either wrapped up in aluminum foil or else stuck on a sheet of paper with sticky tape. It is important that the hair ends and roots are labelled correctly.

A hair analysis of different segments can only be sensibly carried out when care is taken and the hair is free of contamination.