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Preparations for the Evaluation of a Speech Recognition System in Neonatology (U2)

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Abstract

Background: before using a speech recognition system for the neonatal documentation, the underlying neonatal information has to be specified and structured. Up to now, the pre-structuring the first comprehensive examination of newborn (U2) and the respective data set entries has not been described in literature, yet. The common booklet for the documentation of the German U2 does not contain all examinations required nor does it show the choice of all respective finding statements.

Objectives: to set up a documentation standard for the U2 distinguishing the most important diseases/disorders at a limited level of detailing.

Methods: the finding scheme of the U2 has been specified based on the German national recommendation for the U2. Here, the U2 is the first exhaustive examination of the newborn. Due to a lack of detailed descriptions, the U2 has been formalized and arranged in cooperation with experienced medical experts, which carry out the U2 in daily routine.

Results: if all possible finding statements are presented in a hierarchical structure, – even with a small font size – it would cover more than 20 pages. Hence, a more condensed structure has been set up for presentation. If the general practitioner (GP) is to see (a) the finding statements necessary but (b) no more, additional rules can be set up for the masking of finding statements excluded by the results of the prior investigation.

Conclusions: the proposed structure for neonatal documentation serves as a basis for statistical analysis. On its basis, investigation can be carried out about (a) problems during the individual examination, (b) problem with the documentation and (c) the benefits of automated speech recognition systems.

Keywords: Neonatology; Clinical Problem Solving; Decision Support Systems; Clinical Decision Trees; Automated Speech Recognition; Medical Documentation; Specification Requirements.

1 INTRODUCTION

An internationally acknowledged scheme for the representation of the main examinations in Neonatology is still not available. In Germany, a sequence of 9 standard examinations is defined by a national guideline for children [1,2].

According to this guideline, the first examination of a baby has to be carried out right after birth. However, it concentrates on the documentation of the *most important aspects* of the newborn but does not cover *all* aspects that have to be verified.

In the following, we suggest a general structure for the investigation of the second standard investigation of newborn, since this is the first exhaustive examination in the life of a baby. If the evaluation study about the paper-based version proves this structure to be adequate, it will be utilized in the arising speech recognition system (cp figure 1).

Fehler! Es ist nicht möglich, durch die Bearbeitung von Feldfunktionen Objekte zu erstellen.

Figure 1: vision for the usage of the presented documentation structure in an evaluation study of the speech recognition system.

Later, additional rules can be integrated into the Automated Speech Recognition (ASR) to constrain the combination of possible statements. They can help optimizing the process of documentation and enhance the recall of the ASR by including error correction functionality. Such rules will not be specified here and have to be discussed in a future.

2 STRUCTURING THE SECOND NEONATAL STANDARD EXAMINATION (U2)

The second examination – usually performed between the 3rd and the 10th day of life – is the first comprehensive verification of the state of the newborn. Here, the GP inspects all body parts and looks for possible problems. Therefore, the U2 is the major examination for the determination of serious diseases or dysplasias of the baby.

That is why a quality management can most effectively be introduced into the second neonatal examination (U2). Since an according formalization of the documentation of the U2 is missing, it has been developed in an interdisciplinary team including practitioners and informatitioners. The structure presented below can serve as a guideline for documentation as all decision alternatives have been included.

The structure of the U2 presented in this article will serve as a basis for the comparative evaluation of (a) paper-based documentation and (b) documentation with the help of a speech recognition system.

During the preparation of the new guideline special importance has been attached to the grouping of partial aspects. Like this, the GP is supported in the process of documentation. A system can check according to the general scheme, whether the partial aspects have been verified by the GP. Still, the GP has to be able to recognize the respective findings himself. The system can only assist him by reminding the important aspects of documentation.

The documentation can be divided into the sections *General Data about the Infant*, *Anamnestic Data*, *Anatomic Data*, *Motor Functions / Nervous System*, *Signs for Immaturity*, and *Administrative Data*. These sections can again be subdivided as follows:

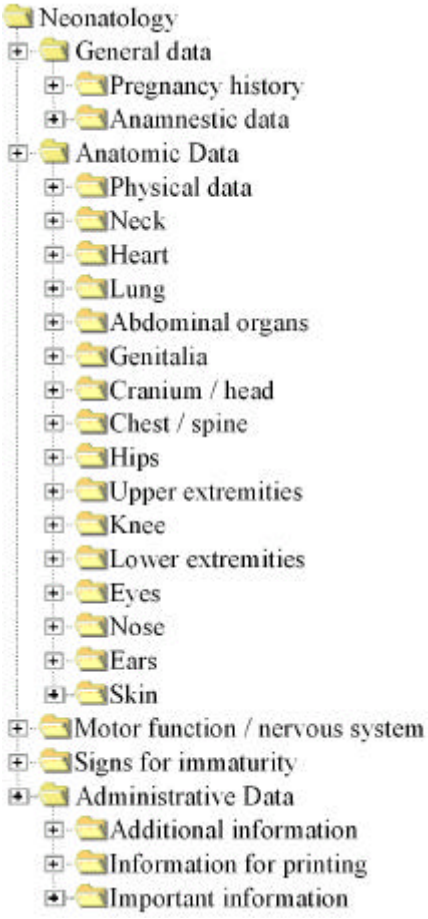


Figure 2: aspects of the second examination of a newborn between the 3rd and 10th day of life (U2).

Practically, the partial aspects are processed top down. A *folder* just summarizes and labels the subordinated content – it does not affect the decision-making itself. An *arrow* (see figures below) marks decision alternatives (within one decision level) belonging together – only one alternative out of them can be chosen. A *check mark* assigns a binary decision – the answer is YES or NO. A *text sign* marks the possibility for free-text entry.

Symmetries of the documentation structure have been used to reduce the size of its representation within this article. E.g. the analysis of the left and the right arm are symmetrically in principal. Therefore, the decision structure has only been shown once and the *symmetry axes* have been enumerated at the highest respective level ("left, right": side of the body; "I, II, III, IV, V": number of the fingers).

Table 1: Legend of symbols.

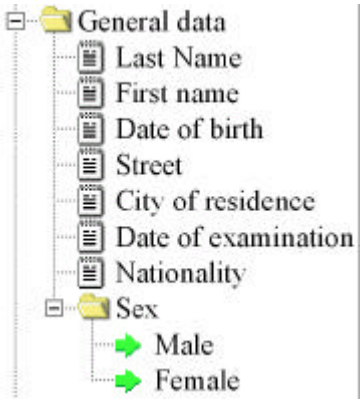
	= Folder, grouping of decisions
	= Choice of <u>one</u> alternative
	= Binary decision (Y/N)
	= Entry of free text possible
Left, Right	= Multiple examinations necessary

The GP can specify "sub-area normal" for each of the main sub-area if there is no respective problem. Like this it can be avoided that the system asks each single question. With other words, the speed of documentation can be enhanced drastically for a healthy baby.

In the following, the documentation structure for the U2 will be shown without further comments. With the help of the structural definitions above, a GP should be able to understand what is required in the specific section.

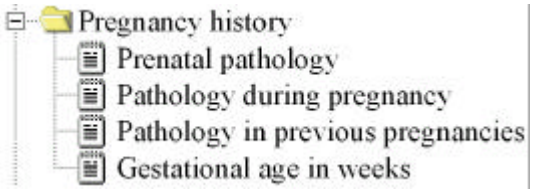
It has to be emphasized, that a classical evaluation of the presented structure is not possible for free-text entry and difficult for the other fields, since a respective measure (golden standard) is missing. In our current evaluation, a team of experienced GPs serves as the Golden Standard.

2.1 General Data about the infant

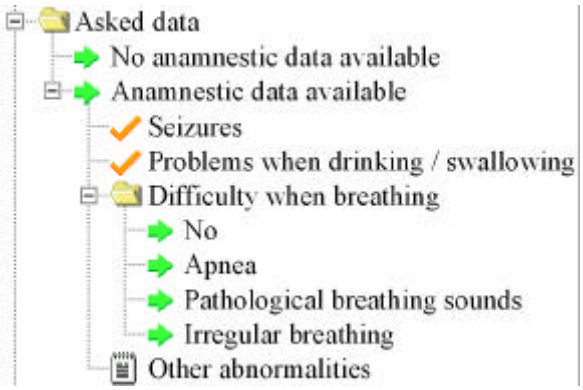


2.2 Anamnestic data

2.2.1 Pregnancy history

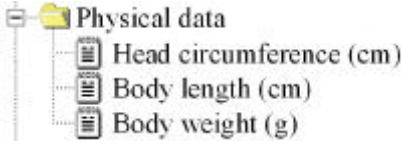


2.2.2 Asked findings

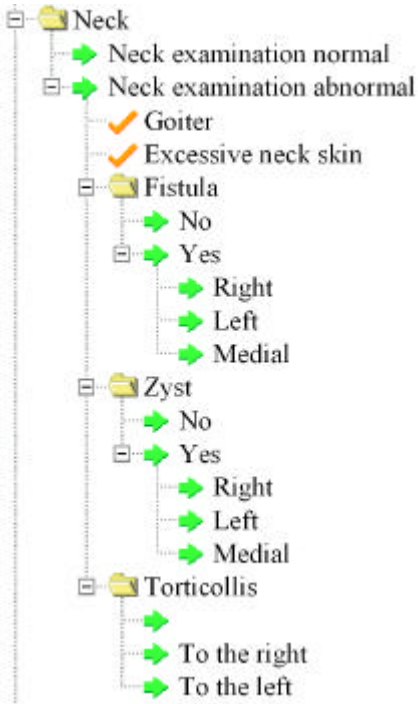


2.3 Anatomic data

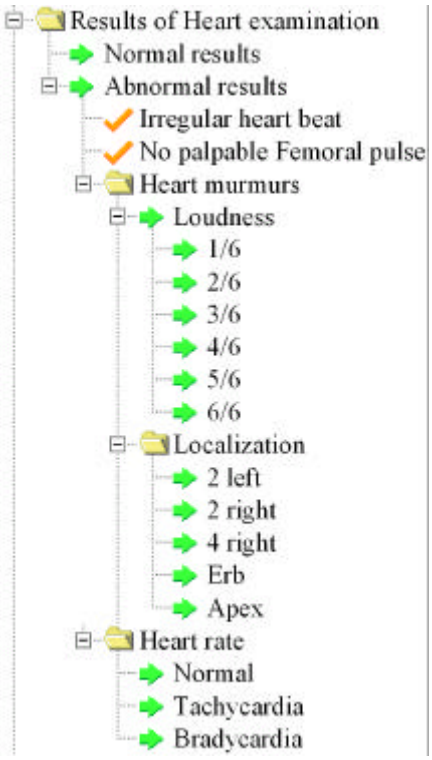
2.3.1 Physical data



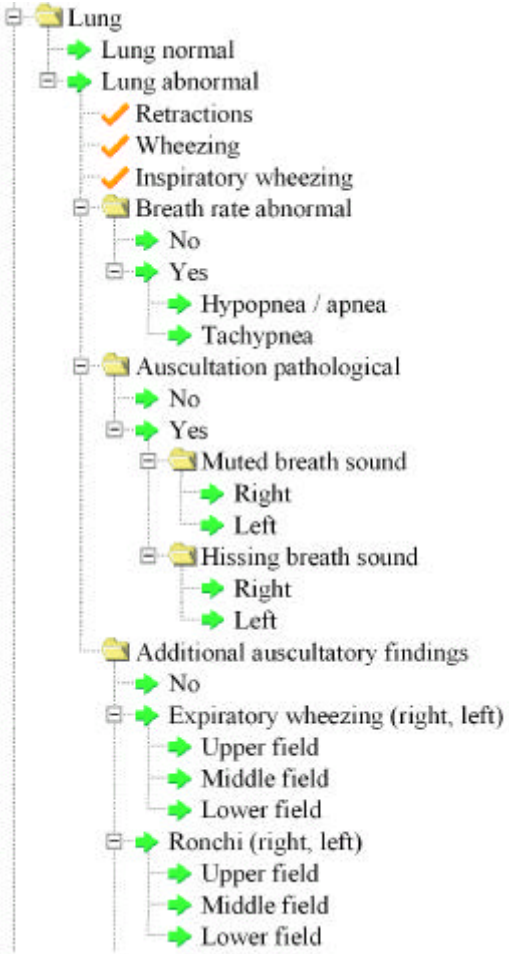
2.3.2 Neck



2.3.3 Heart

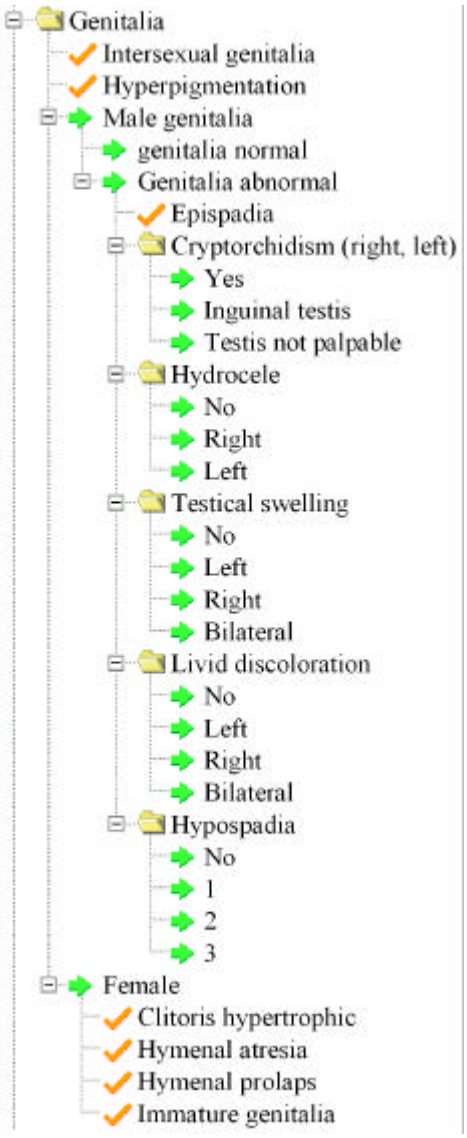


2.3.4 Lung (breathing)



2.3.5 Abdominal organs

2.3.6 Genitalia



2.3.7 Cranium / head

- Cranium
  - Cranium normal
  - Cranium abnormal
    - Brachycephalus
    - Dolichocephalus
    - Trigonocephalus
    - Turricephalus
    - Microcephalus
    - Macrocephalus
    - Retrognathia
    - High forehead
    - Prominent forehead
    - Fleeing forehead
    - Mikro/retrogenie
    - Cranium asymmetric
    - Cranial sutures abnormal
      - No
      - Yes
        - Wide
        - Closed
          - Sagittal
          - Coronary
          - Lambda
    - Fontanelle abnormal
      - No
      - Closed
      - Bulging
      - Caved
    - Birth trauma
      - No
      - Yes
        - Caput succedaneum
          - Frontal
          - Temporal
          - Parietal
          - Okzipital
          - Right
          - Left
        - Cephalhematoma
          - Frontal
          - Temporal
          - Parietal
          - Occipital
          - Right
          - Left
        - Subgaleatic hematoma
          - Frontal
          - Temporal
          - Parietal
          - Okzipital
          - Right
          - Left
        - Skin abrasion
          - Frontal
          - Temporal
          - Parietal
          - Okzipital
          - Right
          - Left

2.3.8 Chest / spine

- Chest / spine
  - Chest / spine normal
  - Chest / spine abnormal
    - Posture defects of the thoracic spine
    - Posture defects of the lumbar spine
    - Spina bifida
    - Increased hair
    - Capillary hemangioma
    - Porus
    - Clavicle abnormal
      - Hypo- / aplasia
      - Fracture
    - Nipple abnormal
      - Swelling
      - Inflammation
      - Accessory nipple

2.3.9 Hips

- Hip
  - Hip normal
  - Hip abnormal
    - Instability of hip joint
    - Other abnormalities of hip joint
    - Ortolani phenomenon
      - No
      - Right
      - Left
      - Bilateral
    - Other signs of dysplasia
      - No
      - Gluteal skin fold asymmetry
      - Difference in leg length

2.3.10 Upper extremities

- Upper Extremities (right, left)
  - Normal
  - Abnormal
    - Shoulder joint abnormal
      - No
      - Contracture
      - Dislocation
      - Hyper extensible
    - Elbow joint abnormal
      - No
      - Contracture
      - Dislocation
      - Hyper extensible
    - Wrist abnormal
      - No
      - Contracture
      - Ulna deviation
      - Radial deviation
      - Hyper extensible
    - Finger joints abnormal (I, II, III, IV, V)
      - No
      - Yes
        - Basic articular hyper extensible
        - Contracture of basic articular
        - Middle articular hyper extensible
        - Contracture of middle articular
    - Upper arm abnormal
      - No
      - Yes
        - Hypoplasia
        - Deformity
        - Fracture
    - Lower arm abnormal
      - No
      - Yes
        - Deformity
        - Fracture
        - Hypo- / aplasia
          - No
          - Yes
            - Radius
            - Ulna
    - Skin creases atypical
      - No
      - Yes
        - Simian crease
        - Sydney line
        - Other anomalies
    - Finger abnormal
      - No
      - Yes
        - Aplasia
        - Preaxial hexadactyly
        - Postaxial hexadactyly
        - Syndactyly
        - Clinodactyly

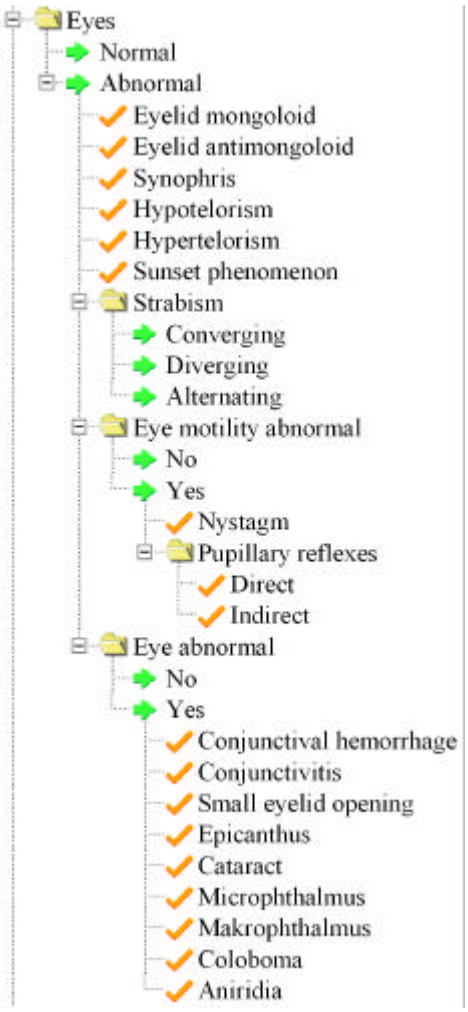
2.3.11 Knees

- Knee joint
  - Knee joint normal
  - Knee joint abnormal
    - Contracture
    - Hyperextensible
    - Genu recurvatum

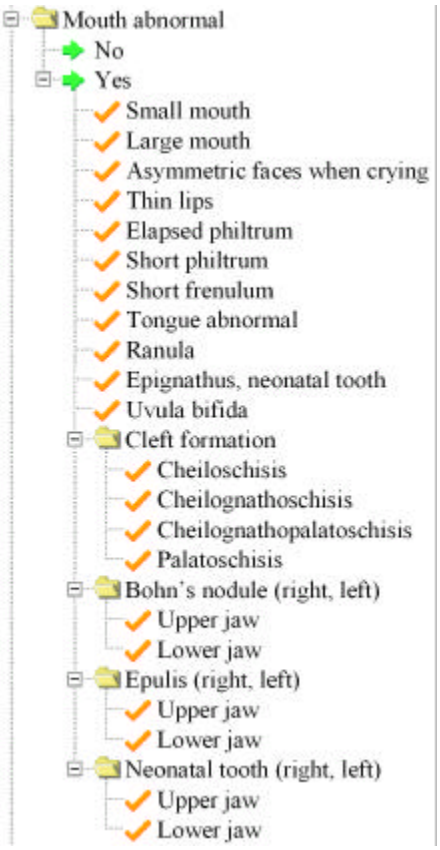
2.3.12 Lower extremities

- Lower extremities
  - Normal
  - Abnormal
    - Toe joints abnormal (I, II, III, IV, V)
      - No
      - Yes
        - Basic joint hyper extensible
        - Contracture of basic joint
        - Middle joint hyper extensible
        - Contracture of middle joint
    - Ankle joint abnormal
      - Contracture
      - Hyper extensible
    - Upper thigh abnormal
      - No
      - Yes
        - Shortening
        - Deformation
        - Amniotic bands
        - Fracture
    - Lower thigh abnormal
      - No
      - Yes
        - Shortening
        - Deformation
        - Amniotic bands
        - Fracture
    - Foot abnormal
      - No
      - Yes
        - Deformation
          - No
          - Club foot
          - Hattock foot
          - Sickle foot
          - Skew foot
          - Climbing foot attitude
    - Toes abnormal
      - No
      - Yes
        - Aplasia
        - Preaxial hexadactyly
        - Postaxial hexadactyly
        - Syndactyly

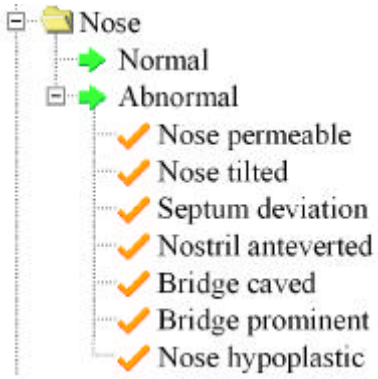
2.3.13 Eyes



2.3.14 Mouth



2.3.15 Nose



2.3.16 Ears

- Ears (right, left)
  - Normal
  - Abnormal
    - Dysplasia of ears
      - Ears engrained
      - Ears rotated backwards
      - Ear hack
      - Cup ears
      - Asymmetric ear size
      - Microtia
      - Dysplasia
      - Anotia
      - Appendix
      - Syrinx
      - Dimpel
      - Atresia of the auditory canal
      - Oto-akustic emission
      - Other dimorphism

2.3.17 Skin

- Skin abnormal
  - No
  - Yes
    - Remarkable whiteness
    - Cyanoses
    - Icterus
    - Staphylodermia
    - Neonatal Exanthema
    - Neonatal pustule melanose
    - Makulopapulose exanthema
    - Pustules exanthema
    - Cutis marmorata
    - Acne neonatorum
    - Edema
    - Exsiccose
    - Dermal sinus
    - Haemangioma
      - No
      - Yes
        - Capillary
        - Tuberous
        - Capital
        - Facial
        - At the strain (chest)
        - At the strain (belly)
        - At the strain (backwards)
        - At the hand
        - At the forearm
        - At the upper arm
        - Size / diameter [mm]
    - Pigment anomalies
      - No Pigment anomalies
      - Pigment anomalies
        - Capital
        - Facial
        - At the strain (chest)
        - At the strain (belly)
        - At the strain (backwards)
        - At the hand
        - At the forearm
        - At the upper arm
        - Size / diameter [mm]
    - Skin injured
      - No
      - Yes
        - Capital
        - Facial
        - At the strain (chest)
        - At the strain (belly)
        - At the strain (backwards)
        - At the hand
        - At the forearm
        - At the upper arm
        - Size / diameter [mm]

2.4 Motor functions, nervous system

- Motor functions
  - Normal
  - Abnormal
    - Apathia
    - Super-excitation
    - Constant asymmetry of tonus, movement, reflexion
    - Muscular hypotonia
    - Muscular hypertonia
    - Peripheral paralysis
      - No
      - Yes
        - Facialis left
        - Facialis rechts
        - Upper Plexus brachialis
        - Lower Plexus brachialis
    - Reflex missing (right, left)
      - No
      - Yes
        - Sucking reflex
        - Moro reflex
        - Hand grabbing reflex
        - Foot grabbing reflex
        - Gallant reflex
        - Pacing reflex
        - PSR
        - Anal reflex
        - ATNR

2.5 Signs for immaturity

- Immaturity
  - No
  - Yes
    - Skin thickness abnormal
    - Nipples immature
    - Foot sole crumples reduced
    - Ear cartilage reduced
    - Sign of negotiation
      - No
      - Yes
        - Washerwoman hands
        - Finger nails overtop

2.6 Administrative data

2.6.1 Additional information

- Tests and Discussions
  - Guthrie-Test applied
  - TSH-Test applied
  - Rachiotis / fluoride prophylaxis discussed

2.6.2 Information for printing

- Printing form
  - Health Insurance
    - AOK
    - LKK
    - BKK
    - IKK
    - VdAK
    - AEV
    - Knappschaft
    - PKV
    - Others
  - Sex
    - Male
    - Female
  - Head circumference (cm)
  - Body length (cm)
  - Body weight (g)

2.6.3 Important information

- Important dysfunctions (1…N)
  - Diagnosis
    - Name
    - Code
    - State
    - Necessary measures
    - Suspicion verified
    - Dysfunction is in treatment
    - First discovery of this dysfunction
  - Other remarks

3 Integrating Speech Recognition in Second Investigation of Neonates

The technology of automated speech recognition (ASR) offers a means of facilitating medical documentation. Numerous speech supported medical applications have been developed and assessed by evaluation studies [3,4], e.g. for command control of medical devices [5], for the collection of medical data [6,7], for template-based medical documentation [8,9], or as an interface for medical expert systems [10,11].

Nevertheless, ASR still hasn't found its way into clinical routine. One of the reasons is an inadequate integration into the respective medical documentation scenario [12]. Hence, it has been the main aim of this article to present the structure of documentation in the U2 of Neonatology. This structure can also be represented formally and thus be integrated into a speech recognition system for the enhancement of the recognition recall.

The presentation of the decision structure within the ASR-system is shown in figure 3. This presentation can also be used as a form for data entry, if the ASR-system does not know the required term.

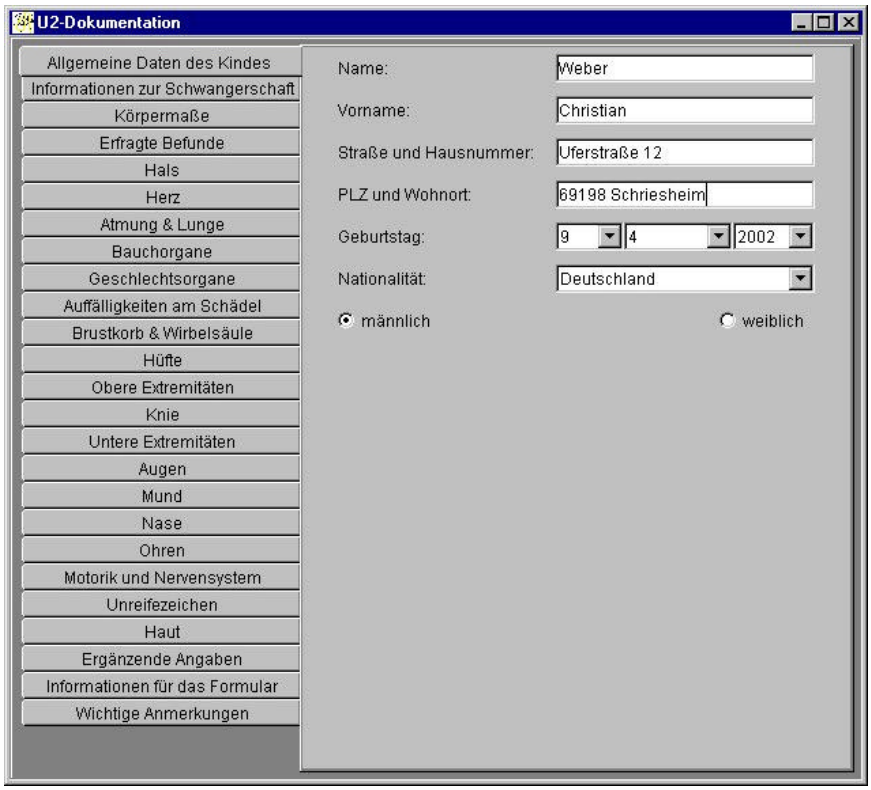


Figure 3: Entry mask of the neonatal speech recognition system with knowledge-based functionality.

4 Summary and Prospects

The official German booklet for the documentation of the examinations of newborn in does not contain all examinations required nor does it show the possible choice of respective finding statements. More detailed or comprehensive literature about the respective documentation could not be found. Hence, a detailed documentation structure for most important second examination, the U2, has been set up and presented in this article.

In a paper-based representation, a structured questionnaire can help guiding the GP during the examination. If the questionnaire is dynamically adapted to the current documentation situation, it can help optimizing the process dramatically. Such an adaptation can most effectively be achieved with a computer system by introducing a speech recognition system.

In the future, a comparison of the documentation structure above applied by (a) a paper-based version and (b) a speech recognition system will be carried out to measure the respective impact for quality management. If the results of this investigation are promising, the research can be extended to other parts of Neonatology. The evolving unified documentation scheme can lead to a more comprehensive exchangeability of the documentation and make wide-area statistical analysis possible.

Acknowledgement

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References

1. Bund. Richtlinie zur Früherkennung von Krankheiten bei Kindern bis zur Vollendung des 6. Lebensjahres (Guideline for the early diagnosis of diseases in children up to the age of 6); 2000.
2. Bund. Kinder- Untersuchungsheft (Examination booklet for children); 2000.
3. Grasso M. Automated Speech Recognition in Medical Applications. M.D. Computing 1995; 12:16-23.

4. Safran C, Gertman P. An Update on Speech Recognition. M.D. Computing 1996; 13:207-9.
5. Mannß J, Lobenhoffer P. Intraoperative drahtlose Steuerung einer Arthroskopiespülpumpe durch den Operateur (intra-operative wireless control of an arthoscopic flushing pump by the operator). In: DLR, Tagungsband Forum "Sprache ohne Grenze (Speech without limits)". Köln; 1997. p. 33-35.
6. Grasso M, Ebert D, Finin T. Acceptance of a Speech Interface for Biomedical Data Collection. AMIA 1997; 1997:739.
7. Feldman C, D S. Pilot study on the feasibility of a computerized speech recognition charting system. Commun Dent Oral Epidemiol 1990; 18:213-5.
8. Klatt C. Voice-activated dictation for autopsy pathology. Computers in Biology and Medicine 1991; 21:429-33.
9. Massey B, Geenen J, Hogan W. Evaluation of a Voice Recognition System for Generation of Therapeutic ERCP Reports. Gastrointestinal Endoscopy 1991; 37:617-20.
10. Isaac E, Wulfman C, Rohn J, Lane C, Fagan L. Graphical Access to Medical Expert Systems: IV Experiments to Determine the Role of Spoken Input. Meth Inform Med 1993; 32:13-32.
11. Wulfman C, Rua M, Lane C, Shortliffe E, Fagan L. Graphical Access to Medical Expert Systems: V. Integration with Continuous-Speech Recognition. Meth Inform Med 1993; 32:33-46.
12. Mönnich G, Wetter T. Requirements for Speech Recognition to Support Medical Documentation. Methods of Information in Medicine 2000; 39:63-69.