: **Regular Anatomical Terminology (RAT), its Pro's and Con's, Digital Terminologies and Possible Solutions**

Compiled by the Nederlandse Anatomen Vereniging and the Anatomical Society of Southern Africa

(a) History of the RAT rules:

Since 2005, several workers encountered issues with the implementation of TA98 in digital resources because of ambiguities in TA98 (Baud RH, Lovis C, Fabry P, Geissbuhler A. Stud Health Technol Inform 2005; 116:653-658; Gobée OP, Jansma D, DeRuiter M. Clin Anat 2011; 24:817-830). January 2013, a first document signified the existence of RAT rules and listed several of their violations in TA98. The resulting internal document "ANATOMICAL TERMINOLOGIES FOR TOMORROW" by Robert Baud, Tom Gest, Paul Neumann and Pierre Sprumont was discussed at the first FIPAT Meeting in Beijing (August 7, 2014). In its introduction, FIPAT's goals for the revision of the *Terminologia Anatomica* (TA98) were mentioned:

(1) To merge the TA98 and the *Terminologia Histologica* (TH 2008) to form a single terminology for adult human anatomy, provisionally abbreviated TAH for *Terminologia Anatomica et Histologica* or *Terminologia Anatomiae Humanae*.

(2) To conservatively revise the terminology to ensure uniqueness and clarity of terms: (a) to improve compliance of the Latin terms to the traditional rules; (b) to improve the precision of the terminology; (c) to adopt and apply new naming rules (Regular Anatomical Terminology); (d) to use terms in the singular throughout.

(3) To make the hierarchical relationships between terms explicit.

(4) To develop definitions of terms.

(5) To encourage the use of the preferred terms in Latin and equivalent terms in other languages.

Discussions within FIPAT's Latin Subcommittee (LSC), following the publication of a paper in Clinical Anatomy (Neumann PE, Baud R, Sprumont P: Human anatomy nomenclature rules for the computer age. Clin Anat 2017; 30:300-302), led to the following solution (document by John Fraher, Chair of FIPAT, January 29, 2018) distributed February 2, 2018 throughout FIPAT:

Potential conflict between the existing terminologies and modifications according to the RA term rules may be avoided on the basis of previously published proposals: The paper by Neumann, Baud and Sprumont (2017), states 'Therefore although rules 9 – 12 (the RA term rules) have so far not been adopted by FIPAT or IFAA, RA terms will be added to the FIPAT databases and presented in future online terminologies along with the official terms.' An appropriate solution which follows is to keep the traditional term as the official one and place the RA term in the synonym column as the preferred synonym. Many terms will be the same in the Official and Synonym columns. The intended value for 'translators, programmers and informaticians' [Paul Neumann], can be indicated in the preamble to the document. This solution would avoid changing the official term, while also facilitating the objective of providing a machine-readable version of the FIPAT terminologies. In many instances, the RA term and the official term are the same. It would potentially reduce controversy and, importantly, be more readily acceptable to the anatomical profession generally.

Recommendations of the LSC:

(1) The LSC proposes the approval of the RA term rules.
(2) Universal, rigid application of the rules is not recommended. Accordingly, the RA term rules should be approved as recommendations, not as fixed rules.
(3) Because of their value in drawing up machine-readable versions, terms modified according to the RAT rules must be identified in each table as a column parallel to that consisting of the official Latin terms, and should be identified as the first official synonym.
(4) The FIPAT mechanism for reaching unanimity on the sets of official terms and synonyms must consist of a detailed review by the Latin Subcommittee of the terms, current and proposed, in each chapter of a terminology undergoing development or modification, as it appears.
(5) For each entity there must be a single official term*.

*: All working groups must use the same official terms. Permitting selective use of the traditional or RAT-modified terms as the official ones would contradict the rigour which is central to FIPAT, would lead to confusion and would undermine FIPAT's authority.

During February 2018, these recommendations were accepted by most of the FIPAT Working Groups.

(b) What are the RAT rules?

In the BNA (1895), there were seven rules of anatomical nomenclature. Five were added in the Neumann et al. (2017) paper.

(1) That, with a very limited number of exceptions, each structure shall be designated by one term only.
(2) That each term in the official list shall be in Latin, each country shall being at liberty to translate the official Latin term into its own vernacular for teaching purposes.
(3) That each term shall be, so far as possible, short and simple.
(4) That the terms shall be primarily memory signs, but shall preferably have some informative or descriptive value.
(5) That structures closely related topographically shall, as far as possible, have similar names.
(6) That differentiating adjectives shall be, in general, arranged as opposites.
(7) That eponyms shall not be used in the Official Nomenclature of Gross or Microscopic anatomy.

New, added rules (the so-called RAT rules) are:
(8) That each name must be unique.
(9) That each name shall consist only of nouns and adjectives.
(10) That each name shall have only one noun in nominative case.
(11) That the standard word order shall have nouns following the noun they modify, and adjectives immediately following the noun they modify.
(12) That nouns in genitive case are generally preferable to adjectives when the modifier means 'of' an entity rather than 'pertaining to' an entity.

(c) Digital terminologies:
The argument made for the RAT rules is that it would enable digitization of the anatomical terminology. In this respect, there seem to be two possible goals that should be distinguished:
(1) To enable **digital handling** of anatomical terminologies. This is needed for translation lookup and for usage in knowledge systems such as the Foundation Model of Anatomy (FMA) or SNOMED that underly health care systems. To reach that goal, there are essential practices/rules, also followed by other anatomical digital resources such as FMA and AnatomicalTerms.info (ATI), that TA2 in fact already implemented without explicating them:

a. **Identify each entity with a permanent meaningless machine-generated ID** (Cimino JJ. Methods Inf Med 1998; 37:394-403; Rector AL. Methods Inf Med 1999; 38:239-252; Baud RH et al. Stud Health Technol Inform 2005; 116:653-658; Baud RH et al. Internal FIPAT discussion paper, 2014; Baud R, ten Donkelaar HJ. Internal document on database implementation of TNA, 2019).

b. **Use complete terms.** In TA98, the complete terms needed to be composed using part of the names of hierarchically 'parent' structures. No rules for the composition were given, however. As a result it is unclear what the exact terms are (Gobée et al. Clin Anat 2011; 24:817-830; Gobée OP. Internal document for AACA, 2018). TA2 expanded all partial TA98 terms, thus solving this problem.

c. **Use singular terms** (Baud et al. Internal FIPAT discussion paper, 2014). This rule is desirable but not essential. TA2 followed this rule partially.

The application of these rules in TA2 is probably the most important contribution of TA2 for digitizing anatomical terminology. It would be good to explicitly mention these new rules too in the listing of rules.

(2) The RAT rules seem to aim at enabling **automated term generation** in different languages. To this aim a mathematically standardized term construction is advocated. However, it is important to distinguish between the aforementioned digitized lookup of translations and the automated generation of terms in different languages:

a. **Lookup** of terms in different languages can be achieved with a lookup table (this is how FMA and ATI work) and further requires the terms to be entered once. The manual entry of a new language would cost approximately 7,500 terms x 15 sec/term = about 31 hours once.

b. With **automated term generation** the terms need not be manually entered but there is a time cost to code grammatical rules for declensions in a new language. Moreover, the required mathematically standardized term construction does not accommodate terms as used in reality. Many languages are already rather regular in their terminologies (French, Spanish and Russian), resulting in conflicts with the automatically generated terms. Most importantly, the RAT rules proposed to this aim necessitate changing a vast amount of the terms, which would probably cause a widespread and long lasting terminology.

Thus the need for the RAT rules to enable this digitization remains debatable.

(d) Pro's and Con's for the RAT rules:
Pro's and Con's are arranged per rule. Not all rules are debatable.

Rule 8: That each name must be unique. To this rule most anatomists would agree. As an example: since **Femur** is used for thigh, it should be **Os femoris** for its bone.

Rule 9: That each name shall consist **only** of nouns and adjectives. This rule is also acceptable to most anatomists. It means in particular the elimination of prepositions such as **ad** and **cum**.

Rule 10: That each name shall have **only one noun** in nominative case (placement of two nouns, both in nominative case = apposition). Aim: shortening and simplifying, for example: Musculus extensor carpi radialis brevis should become: Extensor radialis brevis carpi (Rules 10 and 11).

Pro's:
    (1) They may make the terms shorter.
    (2) The make automated translation possible.

Con's:
    (1) Removing noun appositions by omitting one noun (musculus in the example) may be perceived as non-traditional as well as linguistically and rationally foreign.
    (2) This rule probably increases difficulty as second and third nouns in a compound term must be changed from nominative to genitive case. Genetive cases are declensions and hence probably more difficult to learn and remember than the original nominative case. They may be even more demanding for automated translation.
    (3) Inconsistence in application of this rule between languages: it is not followed in English, since modern English hardly has genitive names (for example: 239 Lateral region of neck; 309 Palmar surfaces of digits of hands; 1639 Anterior ligament of malleus; 3035 Fossa for gallbladder, etc).
    (4) At the Beijing FIPAT Meeting (August 7, 2014), it was agreed to add the word 'muscle' to all the muscles in English to prevent possible confusion with similarly named non-muscular structures (vessels, nerves). It seems not wise to introduce further unclarity in Latin by following rule 10. This destroys the clarity and organization of the Latin terminology that nearly all terms specify the type of structure, be it musculus, arteria, vena or nervus.

Rule 11: That the **standard word order** shall have nouns following the noun they modify, and adjectives immediately following the noun they modify.

Pro:
    (1) A standard word order would simplify learning and foster standardized usage.
    (2) It might simplify automated term generation.

Con's:
    (1) Such a change discards a long tradition in Latin terminology.
    (2) It causes a huge amount of Latin terms to be changed (about 30%). This opposes the policy FCAT (and FIPAT so far) always followed to be conservative in the number of changes of terms in order to not alienate the anatomical and medical world. With this huge amount of changes anatomists and clinicians in countries using Latin as primary anatomical language will find it difficult to follow these rules, thus alienating the anatomical world from the FIPAT terms.
    (3) This rule is conceptually unintuitive: conceptually intuitive terms are ordered consistently in specificity. Specificity is added in Latin by *suffixing* with increasingly specific adjectives ('arteria' is first specified with the suffix 'carotis', then further specified with the suffix 'communis'), in English by *prefixing* with increasingly specific adjectives ('artery' is first specified with the prefix 'carotid', then further specified with the prefix 'common'). The proposed rule 11 might be consistent grammar-wise, but breaks the conceptual order:

a. In a science-based discipline as anatomy, conceptual logic is more important than grammatical logic. The consequences of an embolus originating from an 'arteria carotis', irrespective of it being 'communis', 'interna' or 'externa' are more related than from an 'arteria interna'.
b. This rule causes inconsistency between languages: English follows a conceptual order, Latin in the TA2 a grammatical order.
c. In learning and teaching, the level of detail is increased gradually, first one learns 'arteria carotis', then 'arteria carotis communis/interna/externa'. When term parts are ordered conceptually, omitting part of the term leaves a meaningful remnant 'arteria carotis', but when term parts are ordered grammatically this would leave a meaningless 'arteria interna'. Hence, ordering grammatically, hampers learning and teaching anatomy.
(4) Word order is a matter of interpretation; it is not necessarily fixed in Latin.

Rule 12: That nouns in the genitive case are generally preferable to adjectives when the modifier means 'of' an entity rather than 'pertaining' to an entity. This rule was meant only as a recommendation, not a strict rule. This would cause the change of Lobi renales to Lobi renis.

Some general points of concern:
(1) The argument that the RA rules would make the terms more simple and easier to understand only holds for rule 9, but the opposite holds for rules 10-12.
(2) The argument that the RA rules are valid for all languages does not seem to hold for rules 10-12.
(3) The argument that the RA rules enable 'automated translation' is debatable:
a. Translation by lookup and digital handling of anatomical terminologies does not require these new rules. FMA and ATI do not use these rules. FMA has 120,000 terms and 2.1 mln relations and does not need such rules, because terms are simply (free) labels connected to identifiers. They are only required for automatic term generation, as discussed before.
b. Adding a new language may require less time with a lookup system than with automated term generation that needs to be programmed.
c. It is unsure whether the expected programming advance for automated term generation will indeed be achieved given the inconsistencies between languages in rules 9-12, and the complexity of the genitive case (rules 10 and 12).
d. Automatically generated terms need validation by native speakers and this is sometimes rather time-consuming.
(4) The Latin Subcommittee (LSC) recommended to add the RA terms as first synonyms next to the traditional Latin terms, which should remain the official nomenclature. They stated *"Universal, rigid application of the rules is not recommended. Accordingly, the RA term rules should be approved as recommendations, not as fixed rules".*
(5) Each measure or new rule should be judged by the balance between its benefits and its harm. In general, the policy has always been to conservatively change terminology to not alienate its users (anatomists, clinicians) from FIPAT. Rules that have a large impact should only be applied with explicit positive approval of the affected users. Hence, rules that change about 30% of all Latin terms, such as the proposed rules 10 and 11, should **only** be implemented **with explicit positive approval** by anatomical societies of

countries where usage of Latin anatomical terminology is predominant (Europe, Latin America, South Africa).

(e) Possible solutions:
(1) To apply the recommendation of the LSC with the traditional terms as official Latin terms and their RA version as first synonym or to have both as equivalent terms.
(2) An alternative is to differentiate amongst the proposed new rules:
    a. Rules 8 and 9 meet little opposition, cause only a limited amount of changes, hence they can be implemented.
    b. Rules 10-12, however, meet strong opposition amongst Latin using anatomists and clinicians with the con's outweighing the pro's.
    c. In order to ensure timely approval of TA2 and benefit from the improvements it offers, it is recommended to introduce rules 8 and 9 but to drop rules 10-12 and their resulting terms.
    d. Even though the rules 10-12 are unsatisfactory, it would be good to have standard and easy rules for the word order of terms. A committee of which the majority of members should be primarily Latin using anatomists should study the possibilities for such a standardization of word order, to be applied in TA3 and TNA2 as well.

Conclusions:
(1) To enable digital terminologies changes and new rules are necessary, compared to TA98.
(2) Essential rules to enable digital terminologies and lookup are: usage of meaningless, machine-generated identifiers, usage of complete terms and – to a lesser extent – of terms in singular.
(3) The proposed rules 8 and 9 should be implemented.
(4) The proposed rules 10-12 have major negative effects that far outweigh any pro's. These rules should be dropped as well as the terms following these rules.
(5) A discussion involving the major stakeholders should be started on how to better standardize term order.