Background

Off-Label Use

Off-label use occurs when a licensed drug is applied outside its intended use. The intended use of a drug is documented in the official prescribing information and is based on the related monograph of the German Federal Institute for Drugs and Medical Devices (BfArM) [1]. According to a 2017 EU study, the general prescription of a substance for off-label use in adults is between 7–95 % in inpatient care, and between 6–75 % in the outpatient sector [2]. Numerous guidelines of the Association of the Scientific Medical Societies (AWMF) describe substances used off-label as well as the related level of evidence and assessment. Off-label use may be required for the physician if these guidelines have clearly formulated the conditions for the drug treatment, and the off-label use meets the requirements of the various opinions of the Federal Social Court or relevant opinions of the German Constitutional Court [3–6] or if no on-label therapy is available for the disease [7]. An assumption of costs by the German statutory health insurance (GKV) can in principle only be made if a substantiating application is made by the treating neurologist before the beginning of the therapy as well as a positive opinion of the health insurance medical service (MDK) and/or prior consent of the GKV is available. The extent of the off-label use thus obtained in accordance with the process or outside standard procedure (“tolerated” off-label use) has not been systematically investigated in Germany. With regard to liability, it should be noted that a manufacturer who is aware of widespread off-label use of a product must be held liable in accordance with Section 84 of the German Drug Law [3].

Off-label use is generally associated with an increased risk of adverse drug reactions (ADR), as shown by the recent results of a Canadian cohort study [7]. According to the study, the average rate of ADRs in general-care on-label use patients was 12.5/10,000 patient months versus 19.1/10,000 patient months in a patient group with off-label use [7]. Such findings, together with the recent EU study [2], were the basis for the “Good Off-Label Use Practices” initiative of the European Brain Council [8], the core concept of which is the promotion of significantly improved pharmacovigilance, supported by the European Myasthenia Gravis Association (EuMGA).

Rare diseases: myasthenia gravis

Since 2000, diseases with a prevalence of <5 out of every 10,000 people in the EU have been defined as “rare diseases”. According to a statement by Orphanet regarding myasthenia gravis in Europe [9], this amounts to a prevalence of 1–9/100,000 population. The
epidemiological study by Boldingh et al. [10] found a prevalence of between 11.1 and 14.3 per 100,000 for AChR-positive myasthe-
nia gravis cases. In Canada, there was a small increase in prevalence from 16.3/100,000 (1996) to 26.3/100,000 (2013) which is some-
what related to improved treatment options and diagnostics [11]. On the other hand, new cases of myasthenia gravis between 2.3 and 2.7/100,000 annually seem to be more stable [11].

Approved substances and those included by the Joint Federal Committee (G-BA) and in the Medicinal Products Directive (AM-RL)

In German some substances have been approved by the Federal In-
stitute for Drugs and Medical Devices (BfArM) for the application area myasthenia gravis (Fig. 1). These are generally legacy sub-
stances. However, these were only partially dealt with in the Prepa-
rations committees (in this case Preparation Committee B3 of the Federal Health Office), the work of which was discontinued in 1986 [12]. In 2004 azathioprine was approved in the post-authorization procedure for myasthenia gravis. No subsequent approval was re-
quested for ambenonium chloride which was fictively approved in
Germany until the end of 1991. Although it is possible to use am-
benonium chloride in Germany, an import (according to Drug Law
Section 73 para. 3) from one of the EU member states (France, Po-
land, Hungary) is required to treat the use as an off-label application.

Since the introduction of the “Off-label” expert groups at the
BfArM in 2006, regulation of some substances by decisions of the Joint Federal Committee according to Section 35 c, V of the Social Security Code could be found [13] for mycophenolate mofetil (MMF, 12/03/2013) and intravenous immunoglobulin G (IVIg, 9/10/2013). According to AM-RL Annex VI Part A, these may be
used for off-label applications without prior request by the attend-
ing physician. Thus, the basic therapy was extended so that it could be described as “optimized standard therapy” (see Fig. 1). The costs are assumed by the GKV and do not lead to recourse [4].

Practical application

The substances approved in Germany for myasthenia gravis are
treated as basic therapy in the current guidelines of the German Neurological Society (DGN) (AWMF registry number: 030/087)[14]. Not all approved substances are actually used to treat myas-
thenia gravis.

A Norwegian study [15] analyzed the entire spectrum of pre-
scribed drugs among 850 patients. Of 527 myasthenia gravis pa-
tients receiving immunosuppressants (IS), the ratio of azathioprine to steroids was 32:60%; a survey in Germany revealed a ratio of
77:14% [16] (see Table 1). A survey of the German Myasthenia
Society (DMG) regarding long-term therapy exhibited a distribu-
tion ratio of drugs as show in Fig. 2.

Detection of new antibodies in cases of myasthenia gravis re-
sulted in identification of new variants (e.g., MuSK-positive MG
[17]) which require a significantly different dosage and therapy
planning compared to AChR-antibody-positive myasthenia [18, 19].

Regulation Concept for Off-label Use

Rare disease (orphan) designation

The prerequisites for improving the evidence for new substance
approval for a rare disease have previously been elaborate, presum-
ably not very attractive to a pharmaceutical manufacturer to un-
dertake classical random clinical trials, e.g., to expand the current
authorization. In its “Rapid Report”, the German Institute for Qual-
ity and Efficiency in Healthcare (IQWiG) indicated that the meth-
odological procedure regarding rare diseases is practically the same as for non-rare diseases [3]. However, even with the concept of a rare disease there are “singular cases” [10] or “individual cases”,
which are considered “ultra-rare diseases” (prevalence: <1:10,000), including, for example MuSK-positive myasthenia gravis (prevalence 0.05–0.65/100,000 [10]) or congenital myasthenic syndrome (CMS) [20]. Consequently, Vrinten et al. [21] introduced the study concept of a so-called single-case trial, using ephedrine as an ex-
ample of add-on therapy for MG. For medicinal products, the con-
cept of “rare disease (orphan) designation” (formerly: orphan drug
designation) was introduced by the EMA for a rare disease and its
related constellations. The effect of this, for example, was that
3,4-diaminopyridine, which has been known and used for over 40
years and which according to the German New Prescription Formu-
larv (NRF, no. 22.3) can be prepared by a pharmacy; it can also be
used to treat Lambert–Eaton myasthenic syndrome (LEMS) as a
guideline-compliant therapy and has been approved by the EMA as
an orphan drug (amifampridine). The high costs of this procedure
as well as the procedure itself has been critically discussed [22].

Among the monoclonal antibodies currently in clinical trials, eculizumab has received the rare disease (orphan) designation for
myasthenia gravis (EMA: 7/29/2014); this means that the manu-
facturer has provided proof to the EMA that it provided a “signifi-
cant benefit” (Par. 3 of EU directive 141/2000) [23, 24]. In the
meantime, eculizumab has been approved for the treatment of
“therapy-refractory generalized MG with proven antibodies against
acetylcholine receptor protein” (8/14/2017) [25]. Following ap-
proval by the EMA as an orphan drug in Germany, the procedure
according to the Pharmaceuticals Market Reorganisation Act
(AMNOG) for assessing an added benefit is only required if sales of
the drug exceed a specified amount (currently EUR 50 million). As
a legacy drug, eculizumab is not subject to an AMNOG procedure.

Function of the neurology/psychiatry expert group at the
federal institute for drugs and medical devices (BfArM)

In Germany, regulation of off-label use is following the approach in accordance with Social Security Code V. The joint Federal Commit-
tee (G-BA) assign the Off-label Neurology / Psychiatry Expert
Groups, attached to the BfArM, founded in 2006 to evaluate sub-
stances used off-label. The assignement requires a request to the joint
Federal Commission (G-BA) made by the German health insurance
(GKV), Federal medical association (KBV) or self-help groups to re-
view the prerequisites for the procedure. The assessment is
prepared by one of the external experts nominated by the relevant ex-
pert group. The subsequent evaluation by the expert group is then
prepared according to a coordinated method paper and sent to the
G-BA as a consolidated evaluation proposal, which then passes a
resolution following an decision-making procedure. Either the sub-
stance is thus included in Part A of AM-RL Annex VI (positive) or in
Part B (no off-label application possible). Substances in Part A can
be prescribed directly without prior request by the GKV and costs
assumed by the GKV, if the guidelines specified in the G-BA deci-
sion are adhered to, which are more or less an extension of the tech-
### Table 1: Treatment for Myasthenia Gravis

<table>
<thead>
<tr>
<th>Off-label</th>
<th>On-label</th>
<th>Orphan drug</th>
<th>Guideline</th>
<th>Measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>GKV</td>
<td></td>
<td></td>
<td></td>
<td>Thymectomy</td>
</tr>
<tr>
<td>AM-RL +</td>
<td></td>
<td></td>
<td></td>
<td>Steroids</td>
</tr>
<tr>
<td>GKV</td>
<td>Japan</td>
<td></td>
<td></td>
<td>Azathioprine</td>
</tr>
<tr>
<td>GKV</td>
<td></td>
<td></td>
<td></td>
<td>Methotrexate</td>
</tr>
<tr>
<td>AM-RL +</td>
<td></td>
<td></td>
<td></td>
<td>Mycophenolate mofetil***</td>
</tr>
<tr>
<td>GKV</td>
<td></td>
<td></td>
<td></td>
<td>Tacrolimus</td>
</tr>
<tr>
<td>GKV</td>
<td></td>
<td></td>
<td></td>
<td>Cyclosporin A</td>
</tr>
<tr>
<td>GKV</td>
<td></td>
<td></td>
<td></td>
<td>Cyclophosphamide</td>
</tr>
<tr>
<td>AM-RL +</td>
<td></td>
<td></td>
<td></td>
<td>High-dose IVIg***</td>
</tr>
<tr>
<td>GKV</td>
<td></td>
<td></td>
<td></td>
<td>Intermittent IVIg</td>
</tr>
<tr>
<td>GKV</td>
<td></td>
<td></td>
<td></td>
<td>Immunoadsorption IAD</td>
</tr>
<tr>
<td>GKV</td>
<td></td>
<td></td>
<td></td>
<td>Intermittent IAD</td>
</tr>
<tr>
<td>GKV</td>
<td></td>
<td></td>
<td></td>
<td>Plasma replacement</td>
</tr>
<tr>
<td>GKV</td>
<td></td>
<td>EMA</td>
<td></td>
<td>Rituximab</td>
</tr>
<tr>
<td>GKV</td>
<td></td>
<td>EMA</td>
<td></td>
<td>Eculizumab</td>
</tr>
<tr>
<td>GKV</td>
<td></td>
<td></td>
<td></td>
<td>Other monoclonal antibodies</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Anti-sense therapy</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Etanercept</td>
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<tr>
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<td></td>
<td></td>
<td>Therapeutic vaccination</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Pyridostigmine bromide</td>
</tr>
<tr>
<td>GKV</td>
<td>France</td>
<td></td>
<td></td>
<td>Ambenomium chloride*</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Edrophonium chloride**</td>
</tr>
<tr>
<td></td>
<td></td>
<td>New Prescription Formulary No. 22.3</td>
<td>EMA</td>
<td>3,4-Diaminopyridine (DAP)</td>
</tr>
</tbody>
</table>

**Fig. 1** Overview and approval status of treatment procedures for myasthenia gravis (pharmacotherapy, interventions and surgeries) following the guideline (GL) of the German Neurological Society (gray column). Orphan drug status and on-label use are indicated by region (green). Substances in on-label use and off-label use as approved substance according to the Medicinal Products Directive (AM-RL +) are shown in boldface. Other off-label use requires application to the German health insurance (GKV), possibly legal recourse in case of non-approval by the statutory health insurance. *only approved for myasthenia gravis in France, Poland, Hungary; **only approved in Spain for a pharmacological test; ***by decision of the Joint Federal Committee (G-BA) included in AM-RL Annex VI Part A, reimbursable and prescribable in off-label use without application.

If in an individual case, a preliminary qualified application must be made to the relevant health insurance if the clinical progression requires expansion of the treatment with off-label use of substances, as indicated with second-line substances according to the cur-
rent guideline, but which so far have not been evaluated by the expert group. The application must provide scientific evidence, e.g., according to the current guideline as well as the state of clinical expertise with respect to a case-specific analysis [1, 13, 14]. The application is then reviewed by the MDK and generally approved if the criteria of the Social Security Code opinion dated 3/19/2002 have been met (so-called Sandoglobulin opinion) or the criteria of the Nikolaus opinion (12/6/2006) have been fulfilled [4–6]. Unfortunately, the experience of the treating physician and/or myasthenia experts is often not sufficiently taken into consideration. A negative decision can mean that – in urgent cases – an injunction has to be pursued.

In the long term, according to the EU guidelines, the establishment of disease-specific “Centers of Expertise” (CoE) is planned for such tasks as initiated in Germany by the “National Alliance for People with Rare Diseases” (NAMSE). Currently queries should be addressed to the certified integrated myasthenia center (IMZ; [26]) or specialized myasthenia outpatient clinics.

**Myasthenia Gravis**

**Optimized standard therapy**

Optimized standard therapy is an extended basic therapy, which in addition to the symptomatic, on-demand administration of pyridostigmine bromide [27] usually includes anti-inflammatory treatment with steroids (therapy goal: induction of remission), accompanied by additive long-term immunosuppression with azathioprine, which has a steroid-sparing effect and is intended to maintain and improve the achieved remission (therapy goal: remission maintenance). Azathioprine can be replaced by mycophenolate mofetil, in the case of azathioprine intolerance or ineffectiveness with appropriate dosage and duration of use (or even in case of unfeasible reduction of steroids below the Cushing threshold). In the event of myasthenic exacerbation IVIg can be used as an outpatient add-on therapy for stabilization [28, 29].

**Non-responders**

About 14.8% of all myasthenia gravis patients cannot sufficiently benefit from optimized standard therapy [14, 30, 31]. These patients are frequently steroid responders, that is, they improve and are stable with steroid dosage which generally lies above the Cushing threshold, or they require IVIg or plasma replacement interventions. Nevertheless, they should be regarded as non-responders under optimized standard therapy, since the feared adverse drug reactions of a usually required long-term therapy with steroids must not be accepted [14, 28, 32–34]. In such cases, immunosuppressive therapy with off-label use is employed (second line, e.g., methotrexate, cyclosporin A, cyclophosphamide (see Table 1). This therapy corresponds to an individual treatment, which requires comprehensive clarification and documentation (Table 2; [3, 4, 14]). The situation with respect to juvenile myasthenia gravis is rather more complex [35].

**Therapy-refractive myasthenia gravis**

There are a few patients, probably well below 15% with generalized MG, who do not sufficiently improve by expanded optimized standard therapy, that is, even after the use of second-line immunosuppressants, such as methotrexate or cyclosporin A. This constellation occurring in the course of generalized, often fluctuating gen-

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**Table 1** Use of corticoids and immunosuppressants for the treatment of myasthenia gravis. Norway in the period 2004–2010: of 830 MG patients on pyridostigmine, 636 use an immunosuppressant (data from [15]). In Germany, 744 of 899 MG patients interviewed in 2007 took immunosuppressants (unpublished data).

<table>
<thead>
<tr>
<th>Immunosuppressives</th>
<th>Norway 2004–2010</th>
<th>%</th>
<th>Germany 2007</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Azathioprine</td>
<td>201</td>
<td>32</td>
<td>570</td>
<td>77</td>
</tr>
<tr>
<td>Corticosteroid</td>
<td>387</td>
<td>61</td>
<td>107</td>
<td>14</td>
</tr>
<tr>
<td>Mycophenolate mofetil</td>
<td>23</td>
<td>4</td>
<td>42</td>
<td>6</td>
</tr>
<tr>
<td>Cyclosporine</td>
<td>15</td>
<td>2</td>
<td>15</td>
<td>2</td>
</tr>
<tr>
<td>Methotrexate</td>
<td>10</td>
<td>2</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td>Cyclophosphamide</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>&lt;1</td>
</tr>
</tbody>
</table>

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**Table 2** Recommendations for the indication and monitoring of a planned treatment [3].

1. Comprehensive documentation of therapy resistance
2. Comprehensive information
3. Safety advisory
4. Information for decision-making
5. Written informed consent
6. Comprehensive documentation of progression (exact, closely monitored, personal)

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**Fig. 2** Spectrum and proportion of drugs used in long-term therapy in 763 myasthenic patients. German Myasthenia Society (DMG) modified according to data taken from Wöhrle [16].
generalized MG is referred to as therapy-refractory myasthenia gravis. There is no consensus regarding individual criteria for therapy-refractory generalized myasthenia gravis (TRgMG) (see Table 3 [30, 31, 34, 39]). Therefore, when reviewing the evidence and weighing the benefit/risk profile prior to an intended therapeutic step, the individual case (e.g., MuSK-positive myasthenia gravis) must be established. Due to the varying individual distribution of muscle weakness and crises, this is useful when treating MG. An individual risk/benefit assessment is an additional very important decision criterion, not least for the participative patient decision [14, 19, 28, 32].

Expanded escalation therapy may then mean that in addition to immunosuppressive therapy, there is either indication for a stabilizing long-term therapy by intermittent IVIg administration, or more rarely, consideration should be given to long-term IAD [36] or long-term plasma replacement as an add-on therapy. Likewise, an attempt at remission induction by using monoclonal antibodies, e.g., rituximab in off-label use has shown its value [14, 17, 19, 37–39]. For over 10 years, the use of rituximab, especially for MuSK-positive myasthenia gravis has been a favored successful strategy [39]. Its effectiveness and risk/benefit assessment has been largely seen positively. Of the other monoclonal antibodies mentioned in the guidelines, eculizumab is approved by the EMA and acts as an add-on therapy for ongoing treatment of TRgMG with demonstrated AChR antibodies. As a legacy substance eculizumab is not subject to the AMN0G procedure. The diversified indication within German treatment practice, which is based on an expertise on well over 10 years (“well-established use”), has just begun. Therefore, many questions are still unanswerable, the application will be limited to special cases with generalized MG.

There are very rare constellations of definitely insufficiently treatable myasthenia gravis, the development of which is not always understood (so-called burned-out myasthenia, areactive MG). It remains to be seen whether such disease progressions will be avoided in the future with current therapeutic possibilities. Respiratory paralysis is the most severe impairment. Indication for home ventilation in such cases must be determined in conjunction with neurologists and pulmonologists [41].

**Lambert-Eaton Myasthenic Syndrome (LEMS)**

Immunosuppressive treatment of idiopathic and paraneoplastic LEMS (prevalence: 0.1–0.9/100,000 [9]) with steroids and/or azathioprine is used analogously to myasthenia gravis patients [29, 42], although within the framework of off-label use, since there is no explicit approval for this area of application due to the absence of study data. This therapy is within guidelines, however. Symptomatic therapy uses 3,4-diaminoppyridine (amifampridine), which is available as a formulation according to the New Prescription Formulary (NRF 22.3 5 mg or 10 mg) or as a single-source drug. The EMA issued approval in 2010. In the UK, for example, pricing has led to the previous framework rising from approx. £600 per year per patient to £60,000; the situation seems the same in Germany as well as recently in the United States [22].

**Congenital Myasthenic Syndromes (CMS)**

Congenital myasthenic syndromes are genetically determined together with other ultra-rare diseases (prevalence: 1–2/500,000 [9]), with an increasingly widening spectrum [20]. Apart from approved therapy with pyridostigmine bromide, there are no additional drugs available that are explicitly approved for one of these CMS diseases. However, pyridostigmine bromide is useful for only a few congenital myasthenic syndromes. Administration of 3,4-diaminoppyridine (amifampridine), which is effective in some forms of CMS due to the well-known pathophysiology, must be prescribed as an off-label use upon application to the health insurance. Other substances, some of which can only be obtained through the international pharmacy (for example ephedrine [32, 40, 43]) pose the same requirements for doctors and patients as off-label use. This kind of sustained therapy after a differentiated examination, such as in a neuropaediatric medical center or a suitable specialized outpatient muscle clinic, is required in any case [44].

**Pragmatic approach to the use of off-label substances for treating myasthenia Gravis, LEMS and CMS**

1. The immunosuppressants methotrexe and cyclosporin A are always used off-label to treat myasthenia gravis or LEMS, except in cases of rheumatic secondary disease. There are only exceptionally problems with reimbursement, since these are recognized drugs for treating rheumatism with widespread use, although in this case are used off-label, there is familiarity and understanding on the part of the MDK.
2. Intermittent therapy with IVIg in the long term is a rare indication as add-on therapy in disease phases where stabilizing intervention is required. Since this is so far an off-label use, the individual case has to be differentiated, and rejection by the MDK should unfortunately be expected.
3. The off-label use of rituximab is an attempt to induce remission in the case of therapy-refractive myasthenia gravis. This significant escalation in the ultra-rare disease area should be applied for in advance of long-term outpatient therapy. Here the reputation of a specialized center is recommended.
4. The indication for eculizumab as an add-on therapy in refractory generalized myasthenia gravis is limited to patients with verified acetylcholine receptor-antibodies.
5. The indication for an add-on therapy with eculizumab should be made via designated myasthenia centers.
6. 3,4-diaminoopyridine (amifampridine) can still be produced to treat LEMS by pharmacies according the New Prescription Formulary (NRF no. 22.3). The outpatient prescription of the original preparation requires a corresponding procedure to obtain a special status of the practice (so-called cost-intensive patient).
Conflict of Interest

The author is a member of the Transparency and Independence commission of the Drug Commission of the German Medical Association and member of the Off-label Expert Group (Neurology/psychiatry) of the Federal Institute for Drugs and Medical Devices.

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