Individualization of attention-deficit/hyperactivity disorder treatment: Pharmacotherapy considerations by age and co-occurring conditions

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Greg W. Mattingly1,2,3, Joshua Wilson1,2,3, Leticia Ugarte2,3 and Paul Glaser1

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Introduction
Clinicians often struggle with managing a multitude of issues that arise in patients with attention-deficit/hyperactivity disorder (ADHD) including increased anxiety, stress, depression, and sleep problems; difficulty swallowing and unwillingness to eat; as well as issues with medicating (eg, self-medicating, not medicating, or over-medicating). ADHD often presents not in a vacuum, but instead as part of a complex spectrum of emotional, physical, and sociologic conditions. As physicians, we see these complicated cases daily. For example, we may attend to a child with autism and ADHD whose cognitive abilities are improved with medication but has difficulty swallowing a pill; a teenager with ADHD and depression who feels that his medicine helps but causes unwanted mood-related side effects; a mother who presents to her primary care physician feeling overwhelmed and anxious but forgets to mention that her son was recently diagnosed with ADHD and that she has always struggled with similar symptoms; and a dad who drinks and smokes to try to self-medicate his symptoms.

Further complicating the issue of treatment are the natural change of ADHD symptoms over time, the different manifestations of symptoms based on the environmental context, and evolving comorbidities. Children with ADHD typically present with a constellation of inattentive and hyperactive/impulsive symptoms within the context of external structures such as preschool, school, parental involvement, or other caretaking figures.1,2 Adolescents transition into a period of increasing cognitive demands with longer duration of daily activities, increased self-autonomy, and decreased external structure, which requires an ability to modulate and self-regulate behaviors and activities.3 During early adulthood, there are increased demands of life to alleviate the impairment caused by the changing ADHD presentation, life situations, and comorbidities that may introduce additional challenges. A combination of interventions—or...
multimodal approach—is recommended for most patients to improve the core symptoms of ADHD and overall quality of life, and includes psychosocial and pharmacological options.47,11,12

Given the unique situation for each patient and the shifting ADHD presentation over time, clinicians need to be knowledgeable about all available treatment options. In the United States, there are more than 30 approved medications that are mainly comprised of stimulant formulations providing different delivery mechanisms and durations of effect (Tables 1–3). Many clinicians learn of the basic ADHD medication formulations during training, but they rarely touch on the wider array of delivery systems until after training is complete. This review incorporates peer-reviewed studies and the expert experience of the authors to discuss treatment considerations and pharmacological options for patients with ADHD at each stage of life and for those with common co-occurring conditions.

### Treatment Reduces the Risk of Morbidity and Mortality and Increases the Quality of Life of Individuals with ADHD

ADHD is a common neurodevelopmental disorder that begins in childhood and will persist into adulthood for many patients.49–51 It is associated with significant morbidity,42,43 lower quality of life,44,45 and increased mortality52 in all age groups compared with the non-ADHD population. In a large study of the Danish national population, the mortality rate increased by 86% in preschoolers, 58% in children, and 325% in adults over those without ADHD.46 Furthermore, the risk of death increases in adults with ADHD and a co-occurring psychiatric disorder vs those without another psychiatric condition, the mortality rate increased by 86% in preschoolers, 58% in children, and 325% in adults over those without ADHD.46 In a large study of the Danish national population, the mortality rate increased by 86% in preschoolers, 58% in children, and 325% in adults over those without ADHD.46

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### Pharmacotherapy for ADHD

Medications approved to treat ADHD include stimulants (amphetamine and methylphenidate; Tables 1 and 2) and nonstimulants (atomoxetine, guanfacine, and clonidine; Table 3). Stimulants are the first-line pharmacological treatment for both children and adults because they show greater efficacy, while currently available nonstimulants are often used when a patient is unresponsive to or cannot tolerate stimulants.42,43,45,46 Importantly, interpatient response to each medication class is variable, and the response to one class does not predict response to another.41 If a patient has a suboptimal response to one class of ADHD stimulant, then a trial with another medication class should be initiated to optimize patient outcomes. In our practice, we also find that a patient may respond poorly to one stimulant delivery system, while another delivery mechanism of the same medication class may illicit a better response in regard to symptom reduction, smoothness or duration of effect, or tolerability.

Various medication delivery technologies have been developed to address individual patient needs (Tables 1 and 2). These technologies can provide a nonoral route of administration—as with the methylphenidate transdermal patch (Daytrana)—or extend the release of the drug over the course of the day, allowing for once-daily dosing.88 Extended-release technologies include capsules containing immediate-release beads and beads with a pH-dependent coating for drug release upon entry into different sections of the intestinal tract (eg, Adderall XR,89 Adhansia XR,92 Aptensio XR,97 and MyDayis1); a methylphenidate osmotic release capsule (Concerta);93 an amphetamine prodrug, lisdexamfetamine dimesylate (eg, Vyvanse),94 where a biological enzymatic reaction is required to release active amphetamine95,96; and ion-exchange microparticles containing immediate-release and extended-release medication (eg, Adzenys XR-ODT,92 Cotempa XR-ODT,91 and Dyanavel XR).88

Duration and onset of effect for the various medications should be considered for individualization. Short-acting formulations last for 3 to 6 hours and require multiple dosing per day. Conversely, a single dose of a long-acting formulation provides relief of ADHD symptoms from 8 to 16 hours, depending on the delivery system. Long-acting ADHD medications are associated with better adherence than short-acting medications98 and may reduce medication-related social stigma.99 Onset of effect should also be considered. For the patient with early morning issues, a short-acting stimulant can be prescribed for immediate relief followed by a long-acting
### Table 1. FDA-Approved Amphetamine Formulations for ADHD.

<table>
<thead>
<tr>
<th>Formulation and Delivery Mechanism</th>
<th>Generic Name</th>
<th>Brand Name</th>
<th>Approved Ages</th>
<th>Dosing (Per Day)</th>
<th>Onset of Effect</th>
<th>Duration of Effect</th>
<th>Comments</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Amphetamine</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Short</td>
<td>Amphetamine mixed salts</td>
<td>Adderall</td>
<td>Children ≥3</td>
<td>1–3</td>
<td>1.5 h</td>
<td>4–6 h</td>
<td>Elimination half-life 9.77–11 h for the α-isomer and 11.5–13.8 h for the l-isomer</td>
<td>13–15</td>
</tr>
<tr>
<td>Intermediate</td>
<td>Racemic amphetamine sulfate</td>
<td>Evekeo</td>
<td>Children ≥3 (tablet) Children 6–17 (ODT)</td>
<td>1–2</td>
<td>45 min</td>
<td>9.25 h</td>
<td>Elimination half-life 10.0–11.7 h</td>
<td>16–18</td>
</tr>
<tr>
<td>Long</td>
<td>Amphetamine mixed salts</td>
<td>Adderall XR</td>
<td>Children ≥6, adults</td>
<td>1</td>
<td>1.5 h</td>
<td>10.5–12 h</td>
<td>May be sprinkled on applesauce</td>
<td>19, 20</td>
</tr>
<tr>
<td>Long</td>
<td>Amphetamine</td>
<td>Adzenys ER</td>
<td>Children ≥6, adults</td>
<td>1</td>
<td>1.5 h</td>
<td>10–12 h</td>
<td>Do not add to food or other liquids</td>
<td>21</td>
</tr>
<tr>
<td>Long</td>
<td>Amphetamine</td>
<td>Adzenys XR-ODT</td>
<td>Children ≥6, adults</td>
<td>1</td>
<td>1.5 h</td>
<td>10–12 h</td>
<td>Allow tablet to disintegrate in saliva before swallowing</td>
<td>22</td>
</tr>
<tr>
<td>Long</td>
<td>Amphetamine</td>
<td>Dyanavel XR</td>
<td>Children ≥6</td>
<td>1</td>
<td>1 h</td>
<td>12 h</td>
<td></td>
<td>23</td>
</tr>
<tr>
<td>Long</td>
<td>Amphetamine mixed salts</td>
<td>Mydayis</td>
<td>Children ≥13, adults</td>
<td>1</td>
<td>2 h</td>
<td>14 h</td>
<td>May be sprinkled in applesauce</td>
<td>24, 25</td>
</tr>
<tr>
<td>Long, prodrug</td>
<td>Lisdexamfetamine dimesylate</td>
<td>Vyvanse</td>
<td>Children ≥6, adults</td>
<td>1</td>
<td>1.5–2 h</td>
<td>12–14 h</td>
<td>Capsule: may be sprinkled in water, orange juice, or yogurt Chewable tablet: chew thoroughly before swallowing</td>
<td>26, 27</td>
</tr>
<tr>
<td>Formulation and Delivery Mechanism</td>
<td>Generic Name</td>
<td>Brand Name</td>
<td>Approved Ages</td>
<td>Dosing (Per Day)</td>
<td>Onset of Effect</td>
<td>Duration of Effect</td>
<td>Comments</td>
<td>References</td>
</tr>
<tr>
<td>-----------------------------------</td>
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<td>-----------------</td>
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<td>---------------------------------</td>
<td>------------</td>
</tr>
<tr>
<td>Dextroamphetamine</td>
<td>Dextroamphetamine sulfate</td>
<td>Dexedrine</td>
<td>Children 3-16</td>
<td>1-2</td>
<td>NA</td>
<td>4-6 h</td>
<td></td>
<td>14, 28</td>
</tr>
<tr>
<td>Short</td>
<td>Dextroamphetamine sulfate</td>
<td>Zenzedi</td>
<td>Children 3-16</td>
<td>1-3</td>
<td>NA</td>
<td>4-6 h</td>
<td></td>
<td>29</td>
</tr>
<tr>
<td>Short</td>
<td>Dextroamphetamine sulfate</td>
<td>ProCentra</td>
<td>Children 3-16</td>
<td>1-3</td>
<td>NA</td>
<td>4-6 h</td>
<td></td>
<td>30</td>
</tr>
<tr>
<td>Intermediate</td>
<td>Dextroamphetamine sulfate</td>
<td>Dexedrine</td>
<td>Children 6-16</td>
<td>1-2</td>
<td>NA</td>
<td>6-10 h</td>
<td>Plasma half-life of approximately 12 h</td>
<td>14, 28</td>
</tr>
<tr>
<td>Methamphetamine</td>
<td>Methamphetamine HCL</td>
<td>Desoxyn</td>
<td>Children ≥6</td>
<td>1-2</td>
<td>NA</td>
<td>NA</td>
<td>Not readily available</td>
<td>31</td>
</tr>
</tbody>
</table>

Note: , tablet; , capsule; , liquid; , chewable tablet; , orally disintegrating tablet.

Abbreviations: ADHD, attention-deficit/hyperactivity disorder; FDA, U.S. Food and Drug Administration; HCL, hydrochloride; NA, not available; ODT, orally disintegrating tablet.

*Adzenys XR-ODT and Adzenys ER are bioequivalent to extended-release mixed amphetamine salts (ie, Adderall XR),32, 33 but have not been tested independently in a classroom study.
<table>
<thead>
<tr>
<th>Formulation and Delivery Mechanism</th>
<th>Generic Name</th>
<th>Brand Name</th>
<th>Approved Ages</th>
<th>Dosing (Per Day)</th>
<th>Onset of Effect</th>
<th>Duration of Effect</th>
<th>Comments</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methylphenidate&lt;sup&gt;a&lt;/sup&gt;</td>
<td>Methylphenidate HCL</td>
<td>Ritalin</td>
<td>Children ≥6, adults</td>
<td>2–3</td>
<td>1–2 h</td>
<td>4 h</td>
<td></td>
<td>66, 67</td>
</tr>
<tr>
<td>Short</td>
<td>Methylphenidate HCL</td>
<td>Methylin</td>
<td>Children ≥6, adults</td>
<td>2–3</td>
<td>1 h&lt;sup&gt;b&lt;/sup&gt;</td>
<td>4 h&lt;sup&gt;b&lt;/sup&gt;</td>
<td>Chewable tablet: take with 8 oz of water 30–45 min before meals Oral solution: take 30–45 min before meals Last dose before 6 PM</td>
<td>68, 69</td>
</tr>
<tr>
<td>Intermediate</td>
<td>Methylphenidate HCL</td>
<td>Methylin ER</td>
<td>Children ≥6, adults</td>
<td>1</td>
<td>NA</td>
<td>NA</td>
<td></td>
<td>70</td>
</tr>
<tr>
<td>Intermediate</td>
<td>Methylphenidate HCL</td>
<td>Ritalin-SR</td>
<td>Children ≥6, adults</td>
<td>1</td>
<td>1.5 h</td>
<td>8 h</td>
<td>Take after meals for maximum duration of effect</td>
<td>66, 71</td>
</tr>
<tr>
<td>Intermediate</td>
<td>Methylphenidate HCL</td>
<td>Metadate ER</td>
<td>Children ≥6, adults</td>
<td>1</td>
<td>NA</td>
<td>8 h</td>
<td></td>
<td>72</td>
</tr>
<tr>
<td>Intermediate</td>
<td>Methylphenidate HCL</td>
<td>Metadate CD</td>
<td>Children 6-15</td>
<td>1</td>
<td>1.5 h</td>
<td>8-9 h</td>
<td>May be sprinkled on applesauce</td>
<td>73, 74</td>
</tr>
<tr>
<td>Long</td>
<td>Methylphenidate HCL</td>
<td>QuilliChew ER</td>
<td>Children ≥6, adults</td>
<td>1</td>
<td>45 min</td>
<td>8 h</td>
<td></td>
<td>75, 76</td>
</tr>
<tr>
<td>Long</td>
<td>Methylphenidate HCL</td>
<td>Ritalin LA</td>
<td>Children 6-12</td>
<td>1</td>
<td>30 min–1 h</td>
<td>12 h</td>
<td>May be sprinkled on applesauce</td>
<td>71, 74, 77</td>
</tr>
<tr>
<td>Long</td>
<td>Methylphenidate HCL</td>
<td>Concerta</td>
<td>Children ≥6, adults</td>
<td>1</td>
<td>1–2 h</td>
<td>10–12 h</td>
<td></td>
<td>74, 78</td>
</tr>
<tr>
<td>Formulation and Delivery Mechanism</td>
<td>Generic Name</td>
<td>Brand Name</td>
<td>Approved Ages</td>
<td>Dosing (Per Day)</td>
<td>Onset of Effect</td>
<td>Duration of Effect</td>
<td>Comments</td>
<td>References</td>
</tr>
<tr>
<td>-----------------------------------</td>
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<td>------------</td>
</tr>
<tr>
<td>Long</td>
<td>Methylphenidate HCL</td>
<td>Quillivant XR</td>
<td>Children ≥6, adults</td>
<td>1</td>
<td>45 min</td>
<td>12 h</td>
<td>Shake bottle vigorously for 10 s before dispensing</td>
<td>76, 204</td>
</tr>
<tr>
<td>Long</td>
<td>Methylphenidate HCL</td>
<td>Aptensio XR</td>
<td>Children ≥6, adults</td>
<td>1</td>
<td>1 h</td>
<td>12 h</td>
<td>May be sprinkled on applesauce</td>
<td>76, 89</td>
</tr>
<tr>
<td>Long</td>
<td>Methylphenidate</td>
<td>Cotempla XR-ODT</td>
<td>Children ≥6</td>
<td>1</td>
<td>1 h</td>
<td>12 h</td>
<td>No crushing or chewing; Allow to disintegrate in saliva before swallowing</td>
<td>76, 91</td>
</tr>
<tr>
<td>Long</td>
<td>Methylphenidate</td>
<td>Daytrana</td>
<td>Children ≥6</td>
<td>1</td>
<td>2 h</td>
<td>12 h</td>
<td>Wear for ≤9 h</td>
<td>74, 79</td>
</tr>
<tr>
<td>Long</td>
<td>Methylphenidate HCL</td>
<td>Jornay PM</td>
<td>Children ≥6, adults</td>
<td>1</td>
<td>8-10 h</td>
<td>12+ h</td>
<td>Take in the evening between 6:30 and 9:30 PM to provide early morning symptom control; May be sprinkled on applesauce</td>
<td>80, 81</td>
</tr>
<tr>
<td>Long</td>
<td>Methylphenidate HCL</td>
<td>Adhansia XR</td>
<td>Children ≥6, adults</td>
<td>1</td>
<td>1 h</td>
<td>13-16 h</td>
<td>May be sprinkled on applesauce or yogurt and consumed within 10 min</td>
<td>82</td>
</tr>
<tr>
<td>Dexamethylphenidate</td>
<td>Dexamethylphenidate HCL</td>
<td>Focalin</td>
<td>Children ≥6</td>
<td>2</td>
<td>NA</td>
<td>6 h</td>
<td>At least 4 h between doses</td>
<td>71, 83</td>
</tr>
<tr>
<td>Long</td>
<td>Dexamethylphenidate HCL</td>
<td>Focalin XR</td>
<td>Children ≥6, adults</td>
<td>1</td>
<td>30 min</td>
<td>12 h</td>
<td>May be sprinkled on applesauce</td>
<td>74, 84</td>
</tr>
</tbody>
</table>

Note: ☞ tablet; ☞ capsule; ☞ liquid; ☞ chewable tablet; ☞ orally disintegrating tablet; ☞ transdermal patch.

Abbreviations: ADHD, attention-deficit/hyperactivity disorder; FDA, U.S. Food and Drug Administration; HCL, hydrochloride; NA, not available; ODT, orally disintegrating tablet.

*AAP recommends utilizing methylphenidate as a first choice for preschool aged children.*

*Methylin is bioequivalent to Ritalin,* but it has not been tested independently in a classroom study.
ADHD treatment was not associated with differences in final adult height in a longitudinal study. While this is generally considered a problem for young children, it can also occur for adolescents and adults. ADHD medications are associated with a range of adverse effects, although most are mild and temporary. Patients on stimulants may frequently present with decreased appetite, sleeping issues, abdominal pain, or nausea/vomiting while on stimulant therapy. For adults, increased heart rate and blood pressure may be more common with stimulant treatment. Common atomoxetine-associated adverse effects include gastrointestinal symptoms, anorexia, fatigue, and weight loss. Clonidine and guanfacine are both associated with sedation, somnolence, and fatigue and may decrease blood pressure in rare cases. While serious cardiac complications are uncommon occurrences with both stimulants and nonstimulants, these medications should be prescribed with caution in patients with known cardiac defects. Stimulant pharmacotherapy also slows the growth of children with ADHD (height and weight), however, ADHD treatment was not associated with differences in final adult height in a longitudinal study.

Patient engagement with ADHD pharmacotherapy is another important issue. Patient engagement and adherence to stimulant medication is often low, likely due to many factors including the complexity of renewing a schedule II medication, poor tolerability to stimulants, as well as misinformation, biases, or uncertainty about the use of stimulants to treat ADHD. In a recent study, stimulant prescription renewal was significantly increased when a novel text messaging intervention platform was implemented vs treatment as usual. As the world becomes more digitized, innovative technological solutions for traditional compliance or engagement challenges should be used to support individuals with ADHD to easily access and fill prescriptions for their medications.

### Prescribing ADHD Medication by Age

The challenges, considerations, and recommended treatments for each age group are described below and summarized in Figure 1.

#### Preschool

In 2016, 2.1% of U.S. children aged 2 to 5 years were diagnosed with ADHD and the U.S. Food and Drug Administration (FDA) is now requiring new ADHD medications to conduct preschool studies. Dramatic hyperactivity/impulsivity is the overt presentation in this group. However, these behaviors can be caused by other factors, which is why a comprehensive examination for ADHD is needed before beginning treatment. The American Academy of Pediatrics (AAP) suggests that ADHD can be accurately diagnosed in children beginning at 4 years of age, although children as young as 2 years have been diagnosed. Preschoolers with subthreshold ADHD should also be monitored closely since

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### Table 3. FDA-Approved Nonstimulant Medications for ADHD

<table>
<thead>
<tr>
<th>Formulation and Delivery Mechanism</th>
<th>Generic Name</th>
<th>Brand Name</th>
<th>Approved Ages</th>
<th>Dosing (Per Day)</th>
<th>Onset of Effect</th>
<th>Duration of Effect</th>
<th>Comments</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Norepinephrine transporter reuptake inhibitor</td>
<td>Long</td>
<td>Atomoxetine</td>
<td>Strattera</td>
<td>Children ≥ 6, adults</td>
<td>1-2</td>
<td>3-4 wk</td>
<td>NA</td>
<td>Dosed by body weight</td>
</tr>
<tr>
<td></td>
<td>Alpha₂-adrenergic receptor agonist</td>
<td>Long</td>
<td>Clonidine HCL</td>
<td>Kapvay</td>
<td>Children ≥ 6</td>
<td>2</td>
<td>2 wk</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>Alpha₂₆-adrenergic receptor agonist</td>
<td>Long</td>
<td>Guanfacine</td>
<td>Intuniv</td>
<td>Children ≥ 6</td>
<td>1</td>
<td>3 wk</td>
<td>Up to 24 h per dose</td>
</tr>
</tbody>
</table>

Note: tablet; capsule.

Abbreviations: ADHD, attention-deficit/hyperactivity disorder; FDA, U.S. Food and Drug Administration; HCL, hydrochloride; NA, not available.

*Time to onset of the full effect of nonstimulant medications is extended compared to stimulant medications due to long titration periods.

The duration of effect of atomoxetine has not been formally measured as in studies of stimulant medications. Evidence from clinical studies suggests that once-daily dosing of atomoxetine is associated with efficacy into the evening.
**ADHD Treatment Guide by Age Group**

<table>
<thead>
<tr>
<th>Considerations &amp; challenges</th>
<th>Recommended treatment</th>
<th>Prescribing considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Preschool</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High rate of any comorbidity</td>
<td>First-line: psychosocial therapy</td>
<td>Titrate starting with lowest dose</td>
</tr>
<tr>
<td>Few studies with ADHD</td>
<td>Second-line: add pharmacotherapy, with MPH as the first choice</td>
<td>Higher rate of AEs than older children</td>
</tr>
<tr>
<td>medications in preschool-aged children</td>
<td>Other options: AMP, DEX, ATX</td>
<td>Irritability, emotional outbursts, and repetitive behaviors/thoughts common</td>
</tr>
<tr>
<td>Pharmacokinetic differences compared with older children</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>School</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Girls less likely to be diagnosed</td>
<td>First-line: psychosocial therapy combined with pharmacotherapy, with MPH as the first choice</td>
<td>Lower tolerability of AMP</td>
</tr>
<tr>
<td>ADHD treatment can improve school performance and reduce risk of developing some comorbidities</td>
<td>Other options: AMP, DEX, ATX, GXR and CXR</td>
<td>Safety: closely monitor height and weight of children for signs of growth issues</td>
</tr>
<tr>
<td><strong>Adolescents</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inattentive symptoms more prevalent</td>
<td>First-line: psychosocial therapy combined with pharmacotherapy, with 50/50 MPH and AMP as the first choice</td>
<td>Long-acting formulations with once-daily dosing can improve adherence and decrease misuse</td>
</tr>
<tr>
<td>Increased risk-taking behaviors</td>
<td>Other options: Long-acting AMP, ATX, GXR</td>
<td></td>
</tr>
<tr>
<td>Difficulties at school can be escalated</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poor treatment adherence</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>College</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transition to independent living</td>
<td>First-line: pharmacotherapy with long-acting AMP as first-choice</td>
<td>Preplan time and location to receive medication in college</td>
</tr>
<tr>
<td>At risk for general psychological distress, depression, substance use</td>
<td>If misuse/abuse is a concern: nonstimulant</td>
<td>Openly discuss the social and academic benefits of taking medication</td>
</tr>
<tr>
<td>Higher risk of ADHD medications misuse/abuse</td>
<td>Other option: Long-acting MPH</td>
<td>Emphasize importance of daily structure, exercise, sleep, and positive peer relations</td>
</tr>
<tr>
<td>Poor treatment adherence</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Adults</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ADHD often undiagnosed and undertreated</td>
<td>First-line: pharmacotherapy, with AMP as first-choice</td>
<td>Determine if ADHD can be treated simultaneously with other comorbid disorder(s)</td>
</tr>
<tr>
<td>High rate of comorbid disorders</td>
<td>Other options: MPH, ATX</td>
<td>Consider potential drug-drug interactions of medications for ADHD and comorbid disorders</td>
</tr>
<tr>
<td>Inability to effectively modulate emotions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Excessive mind-wandering</td>
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</tbody>
</table>

**Figure 1.** ADHD treatment guide by age group. Abbreviations: ADHD, attention-deficit/hyperactivity disorder; AE, adverse event; AMP, amphetamine; ATX, atomoxetine; DEX, dextroamphetamine; GXR, guanfacine extended release; MPH, methylphenidate.

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up to one-third are likely to progress to a full diagnosis of ADHD or other mental health problems.\textsuperscript{112}

The recommended first-line treatment for children under the age of 6 is psychosocial intervention, which can include parent training, behavioral therapy, or cognitive training.\textsuperscript{7,11,12} Psychosocial treatments improve ADHD symptoms for this group, with an effect size of 0.75 in favor of intervention.\textsuperscript{113} Adding pharmacotherapy to the treatment plan is recommended when very young patients with moderate-to-severe ADHD do not improve with psychosocial therapies alone.\textsuperscript{7,11,12} Accordingly, in 2016, preschool-aged U.S. children with ADHD were most commonly receiving behavioral treatment (45.8%) or no treatment (36.0%) more often than treatment with medication alone (4.5%) or medication combined with behavioral therapy (13.7%).\textsuperscript{110}

There are five FDA-approved medications for ADHD in children 3 to 5 years of age and all are short-acting amphetamine formulations (Table 1). They include a liquid and tablet form of dextroamphetamine, a tablet for mixed amphetamine salts, and a tablet and chewable form of racemic amphetamine sulfate. While methylphenidate has not been approved for use in this age group, the AAP suggests prescribing a methylphenidate as the first-choice pharmacotherapy because there are more robust clinical studies of methylphenidate than amphetamine in preschool children.\textsuperscript{12} Short-acting methylphenidate administered three times a day improved ADHD symptoms and impairment in preschoolers in Preschool ADHD Treatment Study (PATS).\textsuperscript{114} A recent study demonstrated the safety and efficacy of an extended-release methylphenidate formulation (Aptensio XR) for preschoolers with ADHD.\textsuperscript{115} In case reports, the methylphenidate transdermal system provided improvement in ADHD symptoms for preschoolers.\textsuperscript{116} Atomoxetine reduced ADHD symptoms by at least 30% for 75% of preschoolers in a small open-label study (mean daily dose of 1.59 mg/kg).\textsuperscript{117}

Special prescribing considerations for preschool-aged children include pharmacokinetic (PK) differences, number of comorbidities, and a higher rate of adverse effects when compared with school-aged children. Differences in drug metabolism, elimination, and gastrointestinal function between preschoolers and older children or adults may affect drug PK.\textsuperscript{118} and few PK studies of ADHD medications in preschool-aged children are available. In PATS, preschool children metabolized short-acting methylphenidate at a slower rate, which increased overall drug exposure as compared with older children.\textsuperscript{119} Clinicians experienced with prescribing stimulant therapy to preschool-aged children recommend that while long-acting medications help with both preschool and home activities, there are occasions when a short-acting medication may be appropriate. For example, to cover only a half-day of preschool or to test for adverse effects of a medication before transitioning to a long-acting formulation. Nonetheless, as a general rule for this group, titration should be initiated at a low dose with small increments over an extended period of time.

Comorbid disorders are common in preschool-aged children. About 70% of participants in PATS\textsuperscript{120} and 93% of those in a large Spanish study\textsuperscript{121} had at least one co-occurring disorder, and 57.6% of children in the Spanish study had three or more disorders in addition to ADHD. Importantly, the number of co-occurring disorders in PATS participants inversely affected the efficacy of methylphenidate treatment (effect size decreased with increasing number of comorbidities).\textsuperscript{122} Oppositional defiant disorder occurs in about one-half of preschoolers with ADHD\textsuperscript{120,122}; behavioral strategies may lessen parent–child conflict, potentially contributing to a more effective treatment of ADHD symptomatology. Other frequent comorbid disorders include communication-related issues, anxiety, tics, and obsessive–compulsive problems.\textsuperscript{120,121} General prescribing recommendations for some common comorbid disorders are discussed in the next section.

Clinicians should be aware that stimulants may produce a somewhat different adverse event profile in preschoolers than older children. Decreased appetite, delay of sleep onset, headaches, and stomachaches were the top adverse effects related to methylphenidate for school-aged children,\textsuperscript{123} whereas preschool children taking methylphenidate experienced irritability, emotional outbursts, and repetitive behaviors/thoughts in addition to decreased appetite and sleep issues.\textsuperscript{124} Additionally, there is a higher rate of methylphenidate discontinuation due to adverse events for preschoolers than older children.\textsuperscript{124} With atomoxetine, frequent adverse effects related to treatment were gastrointestinal issues, sleep disturbance, irritability, defecation, agitation, and crying/whining.\textsuperscript{117}

School-aged children

The estimated prevalence of ADHD in children and adolescents ranges from 3% to 10.2%, with the highest rates in North America/ the United States.\textsuperscript{125–127} Most children are diagnosed with ADHD after entry into school,\textsuperscript{128} with boys diagnosed at a higher rate than girls.\textsuperscript{110} The difference in diagnosis by gender is likely driven by the referrer’s perceptions that the level of ADHD symptoms (ie, frequent lack of overt hyperactivity) may cause less impairment for girls, although studies of nonreferred samples find that ADHD severity, associated comorbidities, and impairment are similar between genders.\textsuperscript{129–131} Frequent school age comorbidities include learning disabilities and oppositional defiant disorder, with anxiety, conduct disorder, autism spectrum disorder (ASD), and tic disorders being somewhat common.\textsuperscript{112} Without intervention, children are more likely to struggle academically, be held back a grade, and are at higher risk for developing comorbid depression, oppositional defiant disorder, and/or conduct disorder.\textsuperscript{132}

Pharmacotherapy should be considered as first-line treatment in conjunction with psychosocial therapy for school-aged children, with stimulants preferred over nonstimulants when possible.\textsuperscript{7,11,12} A recent network meta-analysis found that while both types of stimulants are effective at reducing ADHD symptoms, amphetamine was superior to methylphenidate, atomoxetine, and modafinil for symptom improvement in children.\textsuperscript{133} However, due to lower tolerability of amphetamine in this age group, methylphenidate was recommended as the first-choice medication for ADHD. Regarding safety, there are data suggesting that stimulant medication may affect long-term growth (height and weight) of children;\textsuperscript{134,135} thus, clinicians should closely monitor height and weight. Recent studies show that weight recovery treatments (eg, calorie supplementation, drug holidays, and monthly weight monitoring) may facilitate increased weight gain.\textsuperscript{134}

In a systematic review and meta-analysis comparing long- vs short-acting methylphenidate in children (average age 8.25–11.3 years) using both parent and teacher reports on inattention and hyperactivity, no significant differences were found in efficacy and behavior at home or in school between the two methylphenidate formulations.\textsuperscript{135} Additionally, the rate of injuries in children with ADHD was not significantly different in those taking long-acting or short-/medium-acting methylphenidate formulations.\textsuperscript{136} For clinicians considering which duration of action of a medication is appropriate for a school-aged patient, adverse effects and individual needs at different times of day may be of higher importance than how the duration impacts school performance.
Adolescents

According to data from the Centers for Disease Control, about 14% of U.S. teens will have had an ADHD diagnosis at some point. During adolescence, symptoms of hyperactivity/impulsivity begin to wane while inattentive symptoms usually persist. Risk-taking behaviors increase in this age group, which can lead to high rates of injuries, teenage pregnancy, and driving accidents. In our practice, we find that difficulties at school are often exacerbated by increased cognitive demands, decreased external structure, and longer days. Adolescents may not adhere to or may discontinue their medication even though it helps prevent risky behaviors and increases academic performance. In adolescence, we may also begin to see patients diverting (swapping with or selling to peers) or misusing their short-acting stimulants. Engaging the adolescent patient and parents in shared decision making about ADHD treatment and monitoring for signs of diversion and misuse can help improve medication adherence and enhance outcomes. Educating parents about the importance of their active involvement in the management and delivery of medications to their child, ongoing communication between parent and child with respect to treatment effectiveness, and side effects or concerns are key elements to successful therapy. The adolescent’s opinion should also be considered when making medication recommendations.

Stimulants are the recommended first-line treatment for adolescents, with psychosocial therapy also recommended to create a multimodal plan. Strategies that involve organization skills, time management, and planning are fundamental, especially at this stage of development. Methylphenidate is the first-choice medication based on combined efficacy and safety information, although long-acting amphetamines, atomoxetine, and guanfacine are also effective. Use of long-acting formulations with once-daily dosing improves adherence and they are less likely to be misused or diverted.

College-aged young adults

The challenge of adjusting to independent living with more responsibilities is particularly difficult for people with ADHD. College students with ADHD experience higher rates of depression, substance use, and general psychological distress. Misuse of ADHD medications is nearly five times more likely among college students with ADHD than without. ADHD symptoms continue to affect academic performance and contribute to higher levels of stress in college students with ADHD as compared with unaffected students. Stimulants can help to reduce symptoms of ADHD in this age group; however, clinicians should monitor for misuse and abuse of ADHD medications as well as for problems with illicit substances. If the patient has a higher risk for misuse/diversion, a nonstimulant may be prescribed.

The transition from pediatric to adult healthcare is another critical feature of this time; many students will display poor treatment adherence. Several models of transitional care are available and can increase the rate of continued treatment in the college-age population. In our experience, preplanning with high school seniors on where and how they will receive their ADHD medication (ie, sent to their college pharmacy, mailed from their parents, prescribed by their student health system) is beneficial. Daily use of ADHD treatment is improved with once-daily medications and when there is an honest and open dialogue about where treatment makes a difference in their lives. The importance of daily structure, exercise, sleep, and positive peer relations should all be discussed as important areas for successfully coping with ADHD in the college years.

Adults

Prevalence of adult ADHD is estimated at 2.8% globally and 4.4% in the United States. However, adult ADHD is underdiagnosed because it is often mistaken for other disorders and its symptoms may abate with age or be masked through the development of coping mechanisms. Comorbidity is the rule rather than the exception for adult ADHD; greater than 50% of patients will have one comorbid disorder and about one in seven will have three or more co-occurring disorders. Furthermore, adults with ADHD may have sleep problems, an inability to effectively modulate emotions, and excessive mind-wandering. ADHD is undertreated in adults—with only 11% receiving ADHD treatment in the past 12 months, according to a U.S. survey. Pharmacotherapy is the recommended first-line treatment for ADHD. Based on a network analysis evaluating both efficacy and safety of multiple ADHD medications, amphetamine-based medication is recommended over methylphenidate as the first-choice stimulant for adults. Regarding safety, CNS stimulant medications are associated with stroke, myocardial infarction and sudden death, increased blood pressure (2-4 mmHg), and increased heart rate (3-6 bpm). Therefore, patients should be routinely evaluated during treatment if they develop chest pain upon exertion, syncope, or arrhythmias.

Atomoxetine has also shown efficacy in adults; however, due to the lower effect size, it is considered an option for patients at risk for substance use disorder (SUD) or who cannot tolerate stimulant formulations. Guanfacine and clonidine are not approved for use in adults, and few trials in this age group have been performed. A double-blind, placebo controlled study comparing guanfacine to dextroamphetamine for the treatment of ADHD in adults found guanfacine and dextroamphetamine reduced ADHD symptoms on the Diagnostic and Statistical Manual of Mental Disorders, 4th edition (DSM-IV) Adult Behavior Checklist for Adults to a similar extent vs placebo (P<0.05) and guanfacine was well tolerated. In our experience, guanfacine use in an adult may be useful if the patient responded to this treatment in childhood.

Prescribing ADHD Medication for Patients with Common Co-Occurring Disorders

Treatment becomes more complicated when patients present with ADHD and comorbid conditions. Clinicians must determine if ADHD can be treated simultaneously with the other disorder(s), and if not, the most severe disorder should be treated first. Although not reviewed in-depth here, potential drug-drug interactions of medications for ADHD and comorbid disorders are a critical consideration (eg, the interaction of atomoxetine—a potent 2D6 inhibitor—with paroxetine—a 2D6 substrate—where the addition of paroxetine led to increased plasma atomoxetine concentrations, and increased standing and orthostatic heart rate compared with monotherapy). Figure 2 presents an overview of the challenges, considerations, and prescribing recommendations.

Substance use disorder

SUD is a serious condition that emerges as a coexisting disorder in ADHD adolescents with rates increasing into adulthood. ADHD is a risk factor for use disorder of several substances including alcohol, marijuana, psychoactive substances, and nicotine. Patients with ADHD are likely to develop SUD earlier than their peers, and experience a faster transition to a higher severity of...
## ADHD Treatment Guide by Comorbid Condition

### Substance use disorder

**Substance use disorder (SUD)**

**Considerations & challenges**
- Risk of abuse or diversion of stimulant ADHD medication is a concern
- Treatment can reduce ADHD symptoms without exacerbating SUD

**Prescribing recommendations**
- Avoid short-acting stimulants
- Use long-acting formulations that minimize “rush and rebound”
- Some alternative formulations may be less likely to be abused: Concerta (OROS-MPH), Vyvanse (LDX, a prodrug of dexamphetamine), Cotempla (MPH XR-ODT), ATX

**People with ADHD are 5x more likely to develop SUD**

### Neurological disorders

#### Autism spectrum disorder (ASD)

**Considerations & challenges**
- Swallowing issues are common
- Sensitive to adverse effects from ADHD treatment

**Prescribing recommendations**
- Low and slow titration of ADHD medication to monitor adverse effects
- Liquid formulations allow for the smallest dose increments
- To address swallowing issues, prescribe liquid, orally disintegrating tablet, or sprinkle formulations
- Any class of ADHD medication can be beneficial, and response varies for each patient

**~75% of children with ASD are also diagnosed with ADHD**

#### Epilepsy

**Considerations & challenges**
- Limited guidance on the treatment of ADHD in these patients

**Prescribing recommendations**
- MPH is the first-choice ADHD treatment, as it did not significant increase the frequency or severity of seizures
- ATX can also be used, but less is known about safety in epileptic patients

**~1/3 of children with active epilepsy have ADHD**

#### Tic disorders

**Considerations & challenges**
- Reduced the patient’s quality of life

**Prescribing recommendations**
- Stimulants can be effective, but monitoring for worsening of tics is necessary
- ATX can be considered if stimulants exacerbate tics
- GXR and clonidine are often effective at treating ADHD, and may improve tics

**5%–15% of children with ADHD also have a tic disorder**

---

**Figure 2.** ADHD treatment guide by comorbid condition. Abbreviations: ADHD, attention-deficit/hyperactivity disorder; AMP, amphetamine; ASD, autism spectrum disorder; ATX, atomoxetine; GXR, guanfacine extended release; LDX, lisdexamfetamine dimesylate; MDD, major depressive disorder; MPH, methylphenidate; OROS, osmotic controlled release oral delivery system; OTD, orally disintegrating tablet. Downloaded from https://www.cambridge.org/core, on 09 Sep 2020 at 22:50:10, subject to the Cambridge Core terms of use, available at https://www.cambridge.org/core/terms. https://doi.org/10.1017/S1092852919001822.
Psychiatric disorders

Anxiety

**Considerations & challenges**
- Anxiety exacerbates ADHD-related impairment

**Prescribing recommendations**
- Stimulants can be effective, especially when ADHD symptoms contribute to anxiety
- Long-acting, smooth-release formulations are preferred vs those with distinct phases of drug release
- Titrate slowly, and monitor anxiety as well as ADHD symptoms
- First-choice: MPH
- Other options: AMP, ATX, GXR (children only)

**Comorbid with ADHD in**
~15% of children and ~47% of adults

Bipolar disorder

**Considerations & challenges**
- This combination of disorders worsens and complicates each

**Prescribing recommendations**
- Based on recent studies in children, treat bipolar disorder and ADHD concurrently
- Monitor for any worsening of bipolar symptoms

**Comorbid with ADHD in** 19% of adults, also co-occurs in children

Depression

**Considerations & challenges**
- Incidence increases with age

**Prescribing recommendations**
- Severe or suicidal cases: Treating depression takes precedence over ADHD treatment
- Mild cases: Treat ADHD and depression concurrently
- Taking both a stimulant and a serotonin reuptake inhibitor is well-tolerated, and may address both ADHD and depressive symptoms
- ATX is also effective for treating ADHD

**MDD occurs in** 19% of adults with ADHD

Insomnia

**Considerations & challenges**
- Sleep issues are common in patients with ADHD, independent of medication
- Insomnia and sleep issues may improve or worsen with ADHD medication
- Insomnia can occur when initiating an ADHD medication, but may subside over time

**Prescribing recommendations**
- Monitor how the patient responds to different long-acting formulations: Does release at end of day induce or help insomnia?
- With stimulants, adjust dose or try different delivery formulation to address insomnia
- ATX is less likely to cause insomnia
- GXR or clonidine have a sedative effect: use alone or with a stimulant
- Melatonin supplement may help address sleep issues

55%–80% of adults, >80% of children with ≥1 sleep issue

Figure 2. (Continued)
addiction. Individuals whose ADHD persists from childhood into the young adult years may be five times more likely to develop SUD, whereas those with remittent ADHD are similar to the healthy population. The presence of additional co-occurring disorders often occurs in patients with ADHD and SUD.

Past concerns that stimulant treatment in childhood facilitates the later development of SUDs were dispelled by two meta-analyses. Schoenfelder et al revealed that treatment of childhood ADHD with stimulants was associated with lower rates of future smoking compared with no treatment. Humphreys et al evaluated 15 longitudinal studies and found no differences in the risk for developing alcohol, cocaine, marijuana, or nonspecific drug use disorders at later ages between stimulant-treated and untreated children with ADHD.

Many clinicians may be wary of prescribing stimulant medication to an ADHD patient with SUD, as there is a well-known higher risk for misuse and diversion. However, treating ADHD should not be avoided outright given the effect ADHD can have on quality of life as discussed in the beginning of this review. Treatment can reduce ADHD symptoms without negative effects on SUD, and there have not been any specific safety issues with medication in this group. We recommend avoiding short-acting stimulants and to prescribe long-acting formulations that minimize “rush and rebound.”

In patients with ADHD and a specific stimulant SUD (such as amphetamine, methamphetamine, or cocaine), there may be a role for stimulants to moderate the SUD similar to the use of buprenorphine or methadone to improve opioid use disorder. One study examined D-amphetamine in managing methamphetamine use disorders and found a decrease, although not statistically significant, in self-administration of methamphetamine during D-amphetamine maintenance therapy. Further research is necessary to determine whether changes in stimulant dosage or route of administration are beneficial for treatment of amphetamine or methamphetamine SUDs in patients with ADHD.

Some delivery technologies further minimize the abuse potential of long-acting stimulants. The osmotic-release oral capsule of Concerta is less likely to be abused and the nondeformable shell minimizes the potential to grind or snort the medication. The produg delivery technology of lisdexamfetamine (Vyvanse) has been shown to have less likeliness than short-acting amphetamine when taken orally or intravenously. We are aware of one study assessing the impact of concomitant administration of alcohol on the PKs of a stimulant medication in vivo. The amphetamine extended-release orally disintegrating tablet (Adzenys XR-ODT) was studied in conjunction with concomitant alcohol concentrations of up to 40% in healthy adult volunteers. There was no change in the extent of absorption for D- or L-amphetamine and no dose-dumping of the extended release portion of the formulation. Atomoxetine also displays little abuse potential. Appropriate consideration of ADHD treatment in individuals with comorbid SUD may improve overall outcomes.

**Psychiatric disorders: anxiety, bipolar disorder, depression, and insomnia**

**Anxiety**

Comorbid anxiety disorders occur in about 15% of children and 47% of adults with ADHD, and they cause greater ADHD-related impairment. Stimulants may be useful in treating ADHD in children and adults with co-occurring anxiety, especially in cases where the ADHD symptoms contribute to anxiety and emotional distress. Although individual responses differ, we find that methylphenidate is less likely than amphetamine to induce anxiety; smooth-release formulations (ie, where both the peak and offset are smooth, such that medication will gradually absorb into the system, rest at peak levels, and gradually decline) also often induce less anxiety. We recommend choosing a stimulant with a smooth-release profile, and to titrate slowly starting with a low dose. Atomoxetine has also been shown to effectively treat ADHD in patients with co-occurring anxiety disorders. Guanfacine does not exacerbate anxiety in children and may be considered if other options are ineffective.

**Bipolar disorder**

Bipolar disorder is a frequently encountered comorbid condition with ADHD, which may be easily missed. In the National Comorbidity Study, 19% of adults with ADHD had comorbid bipolar disorder. In children with bipolar disorder, coexisting ADHD is fairly common but rates have been highly variable with as few as 4% and as many as 94% in different studies. The combination of the two disorders worsens and complicates each.

Historically, it was recommended to treat bipolar symptoms before treating ADHD; however, recent studies indicate that simultaneous treatment can be effective, and possibly beneficial. In a study of adults with bipolar disorder, the risk of a manic episode was increased with methylphenidate treatment alone, whereas manic episode risk was reduced when methylphenidate was taken with a mood stabilizer (aripiprazole, lithium, olanzapine, quetiapine, or valproate). In two recent large, double-blind studies of medication for bipolar disorder (one of aripiprazole, one of lurasidone) in children and adolescents, stimulant use did not alter the effectiveness of the bipolar medication in the subgroup of patients with comorbid ADHD.

**Depression**

Major depressive disorder prevalence increases with age, ultimately affecting about 19% of adults with ADHD. Additionally, young people with ADHD may experience depression more often when confronted with life stress than people without ADHD. With mild or moderate cases of depression, treatment of ADHD should be pursued, as it can reduce the long-term risk for depressive episodes. A large study in Taiwan found lower rates of antidepressant resistance when individuals with ADHD and depression received combined treatment with antidepressants and psychostimulants vs treatment with antidepressant alone. However, treatment of depression should take precedent over ADHD when it is the most disabling condition such as in major depressive disorder or suicidal cases.

Administration of both a stimulant and serotonin reuptake inhibitor for depression is well-tolerated. Atomoxetine monotherapy was also effective and well-tolerated in an open-label study of adolescents with ADHD and major depressive disorder; although, it was only effective for ADHD symptoms. Caution must be taken when prescribing amphetamine with certain medications, as there is an increased risk of serotonin syndrome when combined with buspirone, fentanyl, lithium, monoamine oxidase inhibitors, selective serotonin reuptake inhibitors, serotonin norepinephrine reuptake inhibitors, St. John’s Wort, triptans, tricyclic antidepressants, tramadol, and tryptophan.

**Insomnia**

Insomnia is common in individuals with ADHD before ever receiving treatment and can be either worsened or improved with...
ADHD medication. One study found >80% of unmedicated children with ADHD had at least one sleep problem including involuntary movement, difficulty falling asleep or rising, sleepwalking, snoring, bed-wetting, or nightmares. Initial insomnia occurs in 55% to 80% of adults with ADHD, with the combined ADHD subgroup showing higher rates of insomnia than the inattentive subgroup. Insomnia is a frequent side effect when starting an ADHD medication, although patients may experience an improvement in sleep quality with appropriate treatment over time. In our experience, a medication with too long of a duration may exacerbate insomnia for some individuals, while, for others, a formulation with a small amount of medication released in the early evening may help to calm the brain, decrease restlessness, and improve sleep quality. If insomnia is an issue with a stimulant medication, the clinician should adjust the dose or try an alternative delivery formulation. Atomoxetine is less likely to cause insomnia and other sleep issues, and can be considered as a second-choice option. Guanfacine and clonidine induce sedation, and may be used alone or in combination with stimulants. Prescribing a treatment such as melatonin to specifically address sleep issues may be needed in certain individuals.

Neurological conditions: autism, epilepsy, and tics

**Autism spectrum disorders**

ASD is characterized by persistent deficits in social communication and interactions in many settings and the presence of repetitive, restricted behavior, interests, or activities. Diagnosis of co-occurring ADHD and ASD was recently endorsed in DSM-V. ADHD and ASD co-occur at all stages of life, with around 75% of children and adolescents with ASD having comorbid ADHD. Similar to ADHD, the symptoms and presentation of ASD change with age. These patients are often extremely sensitive to side effects from ADHD medication; treatment-emergent agitation, increase in stereotypies, or worsening of anxiety can be frequent concerns. To find the optimal dose, we recommend starting with a low dose and titrating slowly. Liquid formulations of methylphenidate (eg, Quillivant XR) or amphetamine (eg, Dyneval XR, ProCentra) can be titrated in very minor amounts and may aid slow titration. Swallowing issues are frequently encountered in this population and liquid, orally disintegrating, or sprinkled formulations may be beneficial. The British Association for Psychopharmacology recommends methylphenidate as the first-choice pharmacotherapy, atomoxetine as the second choice, and guanfacine and clonidine as third-line options.

In our clinical experience, all classes of ADHD medication can prove beneficial in patients with ASD/ADHD and the response varies dramatically between each patient.

**Epilepsy**

Approximately one-third of children with active epilepsy have comorbid ADHD. Evidence-based recommendations on treatment of ADHD in epilepsy are limited. The Task Force on Comorbidities of the International League Against Epilepsy Pediatric Commission recommends methylphenidate as the first-choice treatment because there is a 65% to 83% improvement in ADHD symptoms without significantly increasing the frequency or severity of seizures. At the onset of comorbid ADHD, a stimulant may help to calm the brain, decrease restlessness, and improve sleep quality. Guanfacine and clonidine are often effective at treating ADHD with coexisting tic disorder and may improve comorbid tics.

**Tic disorders**

About 5% to 15% of children with ADHD also have a tic disorder. These patients experience poorer quality of life than those with ADHD alone. Overall ADHD medications can be effective in these patients when used with appropriate care and consideration. With stimulant pharmacotherapy, monitor for possible worsening of tics. At the onset of any new tic disorder, a stimulant is unlikely to worsen tics, and can be considered if stimulants cause tic exacerbation. Guanfacine and clonidine are often effective at treating ADHD with comorbid tic disorder and may improve comorbid tics.

**Conclusions and Future Directions**

Evolving ADHD symptomology and comorbid disorders contribute to the complexity of a treatment plan for patients with ADHD over their lifetimes. Despite this, it is necessary to find the most effective treatment for the individual with ADHD to be able to improve many aspects of his or her life. Notwithstanding the many treatment challenges for patients with ADHD, clinicians have numerous options for FDA-approved ADHD pharmacotherapy allowing individualized medication to meet specific patient needs. Understanding the key challenges of ADHD treatment for different age groups and for patients with various co-occurring disorders is necessary to achieve successful treatment results. Further research is needed to develop better treatment strategies for individuals diagnosed with ADHD and comorbid neurological disorders such as epilepsy, insomnia, and tic disorders. Although not discussed in this review, the association of ADHD with certain inherited neurological diseases such as Fragile X syndrome, Prader–Willi syndrome, Williams syndrome, and Velo-cardio-facial syndrome is becoming evident. Accordingly, further research into the treatment of ADHD comorbid with these inherited disorders would be valuable.

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